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THE

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NEW SERIES.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. I.—JANUARY, 1899.

ORIGINAL ARTICLES.

I.—Fulgurites from Tupungato and the Summit of Aconcagua.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

THE members of Mr. E. A. FitzGerald's expedition to the Chilian Andes in 1896–7[1] made a rather large collection of rock specimens from the higher regions, which has been entrusted to me for examination. The descriptions will be published in Mr. FitzGerald's forthcoming book, but as two are exceptionally interesting I wish them to appear in the Geological Magazine. Permission for this has been kindly granted by him and by his publishers, Messrs. Methuen, to whom I return my cordial thanks.

The specimen of greatest interest is a block of andesite with remarkably fine fulgurites, taken from the actual summit of Tupungato (20,260 feet) by Mr. S. M. Vines, a member of the expedition, who made the first ascent in company with the noted Swiss guide Zurbriggen. The mountain-top is a curving plateau, from which three peaks rise up to a maximum height of about 300 feet. The crater has disappeared, but a little scoria was collected, from which I conjecture that some traces of it may still be found.

The first specimen bears this label: "Found loose in quantities on the top of highest of the three heaps or peaks at summit of Tupungato." It is a block rather irregular in shape, one surface being somewhat convex and the corresponding one concave, but the dimensions may be roughly given as 6 × 6 × 4 inches; it is slightly weathered on the older surfaces (some being fresh fractures). The rock is compact, except for a few minute vesicles; in colour a dull purplish brown or madder, and spotted with small white felspars, the largest of which vary from about one-tenth to one-sixth of an inch in diameter. Under the microscope we find the minerals of early consolidation to be (*a*) iron-oxide; (*b*) brown hornblende, not seldom fairly idiomorphic, very variable in size, and sometimes including grains of felspar and of iron-oxide; (*c*) biotite, only in a very few ill-developed flakes; (*d*) one or two small grains of augite. The felspar, plagioclase, is variable in size; inclusions are inconspicuous; some of the larger grains are broken; these in extinction agree best with andesine, but possibly oligoclase may be also present; a small zircon is seen, and a few little vesicles. The base is a glass crowded with microliths, probably felspar, and tinted with ferrite. Thus the rock is a hornblende-andesite.

---

[1] For a summary of the work, *see the Geographical* Journal, vol. xii, p. 469.

In this block fulgurites are abundant, commonly perforating it, but occasionally forming channels on the surface. The tubes not seldom branch irregularly and vary in size. When fairly circular in shape the diameter ranges from about one-fifth to one-third of an inch, but the latter measurement is exceeded at a fork. The irregularity of their course makes a precise statement impossible. Where the tube shows on a broken surface we see that it is coated at first with a film, hardly so thick as the finger-nail, of a reddish-white or warm-grey tint, over which is a layer of glass of a greenish colour, not unlike some of the lighter-coloured varieties of common bottle glass, and occasionally presenting in this respect and in fracture a superficial resemblance to some varieties of olivine. This glass appears not to form a perfectly regular coating, for sometimes it is almost absent, at others it occurs in patches, the thickness of which is about one-eighth of an inch; while at others the tubes are almost choked by it, but in the last case it forms an aggregate of separate clots rather than a solid mass; the interstices, in many instances at least, being due to bubbles. In a section of one branching tube the aggregated glass extends for about two inches inwards from the surface and for about one inch in a transverse direction at a short thick offshoot.

On careful examination of the material I came to the conclusion that a thin slice could not be made, and that the attempt to obtain it might seriously damage the specimen, so that I have studied the glass by crushing some small fragments and examining the powder under the microscope. The fragments vary in form, but flattish chips are not uncommon, and occasionally they have a rather fibrous structure; curved surfaces are visible, probably indicating the former presence of bubbles. The glass now appears to be of a very pale-yellow tint; clear, and containing but few enclosures. These are either minute bubbles or very small flaky microliths of ferrite and opacite.

In the fulgurites on a specimen of a very similar rock (measuring about 4 × 3 × 2 inches), which was "lying loose in quantities on the summit," the tubes run slightly smaller than in the last specimen; the glass is similar in appearance, but just a shade darker in colour. With a strong lens many minute vesicles, or their broken surfaces, can be seen. Under the microscope the glass is almost the same as in the other case, except that it seems slightly more strongly coloured; bubbles and definite flakes are perhaps rather less numerous, but here and there are tiny brown patches. The white film mentioned above occurs in specimens from both; it appears to be a layer of imperfectly fused rock, the transition from this to the perfect glass being very rapid. It is more or less opaque, but signs of felspar microliths can be detected. Evidently the rock was not materially affected by the lightning for more than about a hundredth of an inch beyond the fused part.[1]

The next specimen is from the actual summit of Aconcagua, which was also collected by Mr. Vines. In the rock itself there is nothing exceptional, but it is interesting as being from the highest point yet certainly reached. This, according to a trigonometrical measurement by Dr. Güssfeldt, is 22,867 feet above the sea.[2] The summit is a square plateau, 75 paces each way, sloping slightly to the north. But few specimens were brought from the uppermost part of the mountain, none of which are scoria. This rock is no doubt from a dyke or a fragment of a flow, so that the crater has probably disappeared even more completely than from Tupungato. Photographs show that Aconcagua has been greatly sculptured by meteoric agencies; at least as much, though on a grander scale, as the Puy de Sancy in Central France. The specimen bears this label: "Loose fragment from the summit of Aconcagua; all the neighbouring rock of the plateau, about 75 yards square, appears to be the same." It is a rather triangular piece of rock, measuring from 5 to 6 inches along the side and about 2½ inches in the thickest part. Its colour is a warm purplish-grey; the old surfaces are rather speckled and have weathered to a reddish or yellowish brown tint; small whitish felspars and a black pyroxenic mineral, with possibly some iron-oxide, can just be detected by the unaided eye, and a few vesicles are present. These larger minerals prove on microscopic examination to be: (*a*) Felspars rather variable in size, often about one-fiftieth of an inch long, much as described above, probably andesine. (*b*) Hornblendes, fairly regular in outline, but occasionally with blunted angles or a corrosion border, sometimes even rounded; pleochroic, changing from pale greenish-brown to a deep sienna-brown; in one or two cases they form a kind of skeleton, owing to the inclusion of small irregularly-shaped felspar crystals. (*c*) A few grains or crystals of augite of a pale-brown tint inclining to green. (*d*) Iron-oxide. The base in which these crystalline grains are embedded is sprinkled with opacite and clouded with ferrite, being apparently a slightly decomposed glass; it is crowded with microliths of plagioclase, which give rather small extinction angles. Hence the summit rock of Aconcagua is a hornblende-andesite. This determination is fully confirmed by a chemical analysis, which has been made for me in the Chemical Laboratory of University

---

[1] Fulgurites from Mont Blanc and from Monte Viso (collected by Mr. J. Eccles) have been described and figured by Mr. F. Rutley (Quart. Journ. Geol. Soc., vol. xli, p. 152, and vol. xlv, p. 60); also (in a serpentine) by Miss E. Aston and the present writer (id., vol. lii, p. 452).

[2] Two peaks of greater elevation in the Himalayas are said to have been climbed, but in each case much doubt exists as to the accuracy of the identification. Pending the determination of the heights lately reached in the Bolivian Andes by Sir M. Conway, and perhaps in any case, Aconcagua is the highest peak which has been certainly scaled.

College (London) by R. W. Gray, Esq., to whom I return my sincere thanks. The following is the composition:—

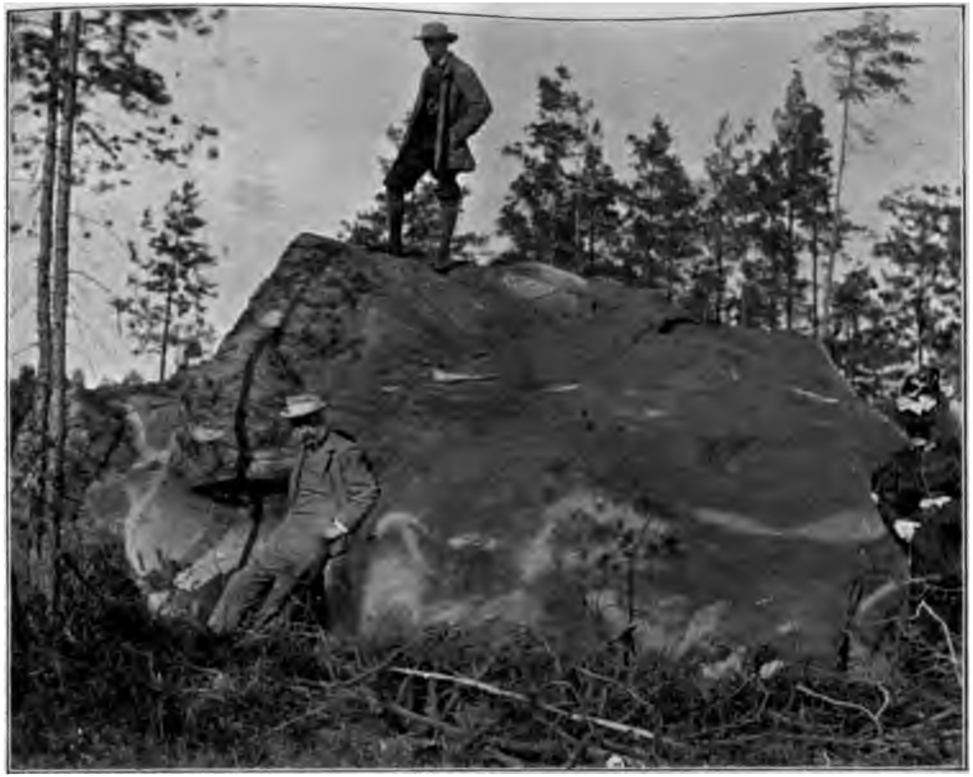
SiO_2	60·32
P_2O_5	0·05
Al_2O_3	17·10
Fe_2O_3	4·74
FeO	1·12
MnO	trace
CaO	3·51
MgO	2·89
K_2O	2·11
Na_2O	5·06
H_2O	1·99
Loss on heating to 100° C.	0·81
	99·70
Specific gravity	2·609

II.—THE SCANDINAVIAN ICE-SHEET AND THE BALTIC GLACIER: A SCEPTICAL COMMENTARY.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

(PLATE I.)

IF the paper on the recent geology of Sweden which has already appeared in the GEOLOGICAL MAGAZINE[1] is sound in argument (and I have not met anyone yet who has answered it), it follows that the views ordinarily current in regard to



Very large rolled and split Crystalline Boulder, from the top

supposed to have carried erratics to the Carpathians on the one hand and to Britain on the other. They would all have been swept away or their stratification destroyed. So would the vast and mysterious åsar, the kames, etc., of whose aqueous origin it seems impossible to doubt.

Hence the Swedish geologists have, without exception, put their great submersion after their Glacial Period, just as their submergence is put by the American geologists after theirs.

Let us now see what follows from this. In the first place, as I argued in a previous paper, following in the wake of Pettersen, the smoothed and polished faces of rock and the hummocky islands on the coasts of Scandinavia, which have been so very generally accepted as presenting the most palpable traces of ice action, are much more likely to have been the result of the wearing of the tide armed with gravel, or stones, or shore ice. Pettersen seems to me to have clearly shown that this was the case on the Norwegian coast, and I believe it to have been equally so on the Lofoden Islands. We cannot suppose that these rocky faces and surfaces should have been exposed, as they must have been, to submarine action and erosion for a long time (as is evidenced by the mollusca in the raised beaches) without having been smoothed and mammillated as they are. The string of islands which fringe the Norwegian coast, the similar islands in the Christiania Fiord, the Mälar, and the Åland archipelago, all seem to me to have one aspect, the same as the archipelago of islands north of America, which have recently emerged from the sea, and their aspect seems due to the like cause; and I cannot separate the inland smoothed rocks of Sweden situated in a region which has been unmistakably submerged from the same category.

If this be so, *a fortiori* must we attribute the striations and scratchings upon these same smoothed rocks to the handiwork of some force acting during or since the submergence. It is inconceivable that these scratches and striæ should have survived the wear and tear of a submergence in these tempestuous latitudes for a long period, and the grating and rubbing of shingle and gravel and shore ice. I cannot, in fact, see how the scratches and striæ on the walls of the fiords in Norway, which have been so frequently quoted as proofs of the handiwork of an ice-sheet, can have been the work of any ice-sheet that was active before the great submergence; and, as we have seen, it is only before the submergence that we have any warrant for believing in such an ice-sheet at all. It is not only that the sea must have worn away all such minute marks, but we actually have evidence that it cut back the rocks, forming a series of recessed terraces called *strandlinier.* How could glacial striæ survive a cutting back like this?

In regard to the long striæ which traverse the Dovrefelds for many miles, and often run athwart their line of drainage, it seems impossible to understand how, if the ice culminated on the fells and moved outwardly in various directions, it could have cut and scored these straight long striæ and incisions. These striæ, running in straight lines right across the watershed of the country, cannot be separated from the aberrant course followed by many of the Swedish boulders, and described, *inter alios*, by Professor James Geikie in the following paragraph. He says: "Dr. Törnebohm and Professor Högborn have shown that the glacier-carried erratics of Jemtland demonstrate that the ice has passed from east to west—that is, right against the slope of the land; and, according to Keilhan, similar blocks which could only have come from Sweden are now found in Trondhjems Fiord; while Pettersen has recorded similar facts in connection with the glacial phenomena of Northern Norway. The most remarkable circumstance in connection with some of these blocks consists in the fact that they occur at a considerably greater height than the rock from which they have been derived. Thus, at Areskutan, Törnebohm found blocks at a height of 4,500 feet which could not possibly have come from any place higher than 1,800 feet." ("Great Ice Age," 3rd edition, p. 424.)

I cannot understand the process by which these striæ are supposed to have been made, and these blocks to have been moved, by a great ice-sheet culminating, not on the mountains, but in the lowlands far away to the east of the mountains, and moving, not along the lines of easiest descent and of least resistance, but marching right across the high range of mountains. It seems to me as likely a process as that the Rhône glacier should have climbed up Mont Blanc in preference to flowing down the Rhône valley; and the phenomena in question seem to me to be only consistent with a great and serious alteration in the surface contour of the country, accompanied by some widespread diluvial movement either after or coincident with the making of the striæ and dispersion of the boulders.

Let us now turn to other characteristics of the boulders and erratics, which are such a prominent feature in the surface beds of Sweden and Norway. The Northern Glacial geologists differ from our own in one important particular, namely, in discriminating between the different materials which form their surface beds. They would be surprised if they came to England and saw how it is the fashion here to describe as glacial, beds consisting entirely of rolled gravels or boulders, often intercalated with pockets and layers of stratified sands and false-bedded brickearths: beds quite different to true moraine materials, which are heterogeneous, unsorted, and consist of a mixed mass of mud, sand, and stones, chiefly angular and unrolled.

In Sweden the rolled and rounded gravels and boulders are directly attributed to the action of water, not water running in so-called subglacial streams, which by our geologists are supposed capable of travelling to and fro everywhere, irrespective of the contour of the country, but to submarine submergence. I cannot understand how these millions of boulders of all sizes and materials should have been manufactured in the transcendental and largely imaginary boulder mills which are postulated as having underlaid the ice-sheet. A great proportion of them are composed of rocks which are not found rising and beetling above the general level of the country, but which must have been deeply covered by the ice-sheet, if it ever existed; and as I am no believer in what the Americans call the plucking theory, or the tooth-drawing theory as Professor Bonney calls what he so ably denounces, I consider this a fatal objection to the subglacial formation of such boulders. Nor can the enormous masses of rock, as large as small houses, whose rounded angles clearly testify to their having been rolled, be conceived as rolled by any subglacial streams on this side of Saturn! These rolled boulders seem to me to testify most completely to the handiwork of the sea during a widespread submergence, a submergence which, as we have seen, is postulated by every inquirer into Scandinavian geology, native and foreign, who has explored the country. I take it, in fact, that these rolled boulders and pebbles were made by the same force and at the same time as the rock surfaces of Scandinavia were polished and mammillated.

The Swedish geologists do not treat these rolled boulders, and the beds in which they chiefly occur, as glacial, but as water-worn and arranged by water, and notably is this the case in the great deposits of them found in the åsar, eskers, etc.

What the Swedes treat as moraine-stuff is the accumulation in certain places of masses of angular débris, mixed with sand or loam, which occur in certain limited areas and which have the internal structure of moraines.

It is a curious and eloquent fact that whereas these two sets of deposits generally occur separately, they also sometimes occur mixed, and they occur mixed in deposits like the åsar, which seem unmistakably to be of aqueous origin. Whatever the ultimate origin of these accumulations of angular or subangular materials, they would appear, therefore, to have existed when the submergence was still in operation. If, however, they had existed throughout the period of submergence, how is it they have not been sorted into different materials, according to their specific gravity, and how is it the stones have not been rolled into boulders and had their edges rounded? I cannot see how the Swedes get over this dilemma. They clearly put their Glacial Period, to which they attribute these so-called moraine heaps and mounds, before their great submergence. How, then, did these materials escape being water-worn?

According to the view I have maintained, these angular stones and blocks, which occur in such vast numbers in certain districts, like Dalecarlia, are the direct result of the breaking of the strata into fragments, when the district of Central Sweden was violently upheaved, and the waters which then covered a large part of it and of Finland were scattered and driven in all directions. In such a case there would be no rounding or rubbing of the angular débris. The same waters which piled up the rounded boulders into mounds and heaps would pile these up also, and in cases where the two were in proximity to one another they were inevitably mixed.

Let us now turn to another point, namely, the traction and movement of the very large blocks. This is a subject of great difficulty to most geologists, and makes many of them accept the extreme glacial view. They fancy that ice, and ice only, is the possible motive engine of the stones. The fallacy of this argument is well tested in Scandinavia.

The one thing which perhaps has struck me more than any other, in travelling through those parts of Central Sweden where the great stones occur most frequently, is the fact that we cannot separate them from the beds of stratified sand, the åsar, etc., which occur there, and are so clearly of aqueous origin. This provenance of many of the boulders is not disputed. Thus Professor Geikie says: "Erratic blocks are frequently found perched upon the top of an ås, or plentifully sprinkled along its sides, and sometimes also they occur in the interior, especially towards the top or the base." Again, he says: "Frequently the shelly clays exhibit disturbed and contorted bedding, and they often contain erratics." And further: "The beds next in succession consist of marl clay, sand, and gravel. They contain numerous shells of Baltic species, and large erratics often rest upon them."

I have myself verified this fact in various parts of Sweden, and notably in the case of the åsar and mounds north of Upsala, whose backs are strewn with great boulders. How can we account for the moving of these great stones by ice? The postulated ice-sheet, according to the Swedish geologists and those who have written on the subject from personal knowledge of the country, had passed away long before these stratified sands and åsar were laid down. It is impossible, therefore, to attribute the planting of the stones on their very backs to the operations of an ice-sheet. If they were not carried and deposited by the ice-sheet it is still more difficult to understand how they could have been moved by icebergs or ice-rafts. Icebergs are only the calves of glaciers. The only stones they carry are the stones carried by the glaciers. Now, glaciers do not have great masses of stone of the size of huts frozen into their feet, and if they had they could not roll them along so as to rub off their angles as these great blocks are rubbed. If they had been carried on the glaciers' backs they would be quite unweathered and angular. Apart from this, the stones themselves come from districts which could not at the time of the great submergence, when these supposed icebergs were floating about, have been exposed to the air, but must have been deeply covered with water. The water must, in order to deposit these stones, have covered the tops of the åsars themselves many fathoms deep. If this were so, how could icebergs or ice-rafts pick up the stones at all? People who talk of icebergs and ice-rafts in this fashion should visit the country and see where the beds lie *in sitû* in Dalecarlia, whence the big stones have mainly come, and they will realize how impossible and fantastic the notion is, that either an ice-sheet, or icebergs, or ice-rafts could have moved them from their original homes to where they are now found in Sweden. Ice in any form, therefore, seems quite a transcendental cause to appeal to for the transport and deposition of these blocks, and if we put ice aside, then, as I have said over and over again, there is only one force which seems competent to account for the portage in question, and which also accounts for the other correlated phenomena, and that is water on a great scale moving rapidly—such a mass of water as would be sped along if North Central Sweden were to be rapidly upheaved and discharge in all directions the waters that once covered it.

Another word with regard to the distribution of these stones. If we want a good test of whether a large mass of scattered angular boulders or erratics were distributed by land-ice or water, we shall find it in this fact, that whereas water in moving along sorts out the stones it carries, according to their weight and size, dropping the big ones first and the lesser ones afterwards, a mass of moving ice like a glacier does not sort them at all; it carries on its broad back a stone as big as a house just as easily and just as far as it carries a pebble. This can be tested in any Alpine valley. Now, if we apply this test to Scandinavia, we must conclude that the stones were carried by water; a few very big ones were no doubt carried a long way, as they would naturally be by a vast torrential flood, but the great mass of them are arranged roughly according to their specific gravity, getting smaller as we go farther away from their place of origin.

Let us now turn to another feature of the so-called glacial deposits of Sweden which seems to me quite inconsistent with the so-called ice-sheet theory. This is the distribution of the marls and limey clays, of which a beautiful map has been published by the Swedish surveyors. If we examine them, and also note the blocks of Baltic limestone which occur in Sweden, we shall find that we establish at least two centres of distribution: one from the Silurian limestones of Gothland, notably from the district of which Kinnekulle is the focus, and the other in the district north-east of the Mälar lake, from which the limestone has apparently been recently and violently stripped, leaving only a small insular piece near Gefle, but of which the remains both in the form of powdered limestone and of blocks and boulders occur over a wide area.

What I am urging is, that anyone who will examine the two areas just named, where the Silurian débris occurs, will realize how desperately difficult or impossible it is to account for this particular phenomenon by ice action of any kind, and how unmistakably it points to a great breakage of the surface and the distribution of the débris by water.

It seems to me that whenever we apply a really critical analysis to the separate facts and factors of the problem as presented by the surface of Scandinavia, we are met by the same stupendous difficulties in attributing them to ice action. Nor would the idea have dominated men as it has if they had not for so long done homage to the Baal of a spurious Uniformity and the notion that Nature never acts in a violent and spasmodic way. The great argument of all, however, remains, and I have pressed it in season and out of season. It is not a geological one but a physical one, not based on fantastic speculation but upon precise mechanical laws, and that is the impossibility of understanding how any ice-sheet could have existed in Scandinavia of such portentous depth and potency as to force débris thence to the Carpathians on the one hand and to Holland and Britain on the other.

All the evidence I know points to Scandinavia being higher now than it was in so-called Glacial times, and points to its having risen at least 600 feet since the drift was distributed, and we have no evidence that I know of that it was ever higher than it is now. As it is, the elevation of the Dovrefelds is so moderate that it is impossible to understand their nursing a great ice-sheet. In fact, we know that such an ice-sheet never covered their higher parts or those of the Lofodens, for they are rugged and not smoothed by ice. Pettersen has proved as clearly as can be that whatever ice was upon them in so-called Glacial times could not drive the stones even as far as the string of islands down the Norwegian coast. It is incredible, therefore, to suppose that any ice they supported could have driven the stones right away to Smolensk or to Brunswick. The contention that it did so, which is repeated, parrot-like, by one writer after another, seems to me, in the absence of some evidence of its physical possibility, completely childish.

But, as I have before remarked, the majority of the stones, and notably those found in Britain, did not even come from the Dovrefelds or the higher parts of Scandinavia, but from the lowlands on the borders of Viken and the undulating plains of Central Sweden. *A fortiori* it is impossible to understand how any ice-sheet could have taken up the stones there and carried them to where they are found.

The arguments I have used in this and the preceding papers have been entirely or almost entirely geological. There remains, however, another, which I will only shortly refer to, namely, that based on the biological evidence.

According to the glacialist, the whole of Scandinavia was covered with ice for a long period, and this ice, radiating from that peninsula, extended for hundreds of miles south of the Baltic. During this period we are to believe that the whole fauna and flora of this immense region was completely extirpated, or rather migrated, goodness knows how and goodness knows whither. When the ice had disappeared it is supposed to have gone back again unchanged and unaltered. This monstrous paradox has been widely believed in by geologists, and been passed on by them to the zoologists and the botanists.

I tried to show in a former paper how this theory, which had also been applied to Greenland, was quite at issue with the evidence available from that much more northern land, and I have no doubt myself that in Scandinavia also the theory of the extermination of all plants and animals during the Drift period and their reintroduction afterwards is just as fantastic. I do not know of a tittle of evidence in favour of the view here condemned except and beyond the mere fact that, if the glacial theory as usually taught be sound, it necessarily involves adding this most tremendous hypothesis to it and to our geological creed. To those who, like myself (if there be any), who utterly repudiate the glacial theory, there is no such necessity. I do not believe that the animals and plants of Scandinavia were entirely driven out and sought shelter in some unknown region, perhaps in Jermyn Street or the University of Edinburgh, and that they returned again in all their fulness and completeness, without variation and change, to reoccupy their old country.

I believe, on the contrary, that the animals and plants of Scandinavia are directly descended from their ancestors, who lived in the same country before the distribution of the drift, and that they have lived an unbroken life there since. A few species were doubtless destroyed by the revolution which distributed the drift; a few have probably disappeared from the natural decay that goes on everywhere among species as among individuals. The uplifting of Scandinavia to 600 feet or more may have caused the disappearance of others, or their migration to lower levels, but in the main and substantially there has been no break in the continuous animal and vegetable life in Scandinavia. The diluvian movement in which I believe, and whose handiwork I have tried to describe, doubtless caused temporary desolation in those districts over which it passed, but it did not pass everywhere, and those localities which were depopulated temporarily were presently occupied by colonists from other localities which had escaped the scourge. This is my view, and assuredly if science is based upon the discovery of rational and adequate explanations of the economy of nature, the biological argument here used must weigh a great deal in deciding the problem. I only use it, however, as a subsidiary argument.

Let us now consider a subordinate problem with which the one I have discussed in this and the previous paper is closely bound up, namely, the so-called Baltic Glacier. The Baltic is a great stumbling-block to the extreme glacial men. This vast trough intervening between Scandinavia and Germany and Russia, offers a stupendous difficulty to any glacial geologist (if there be one) who takes notice of ordinary mechanical and physical laws.

The Scandinavian débris which is found in North Germany as far as the Carpathians is supposed to have been carried thither by a vast ice-sheet, which first traversed the Baltic right athwart its length. Neglecting all the usual methods adopted by moving liquids and viscous substances, having found itself in this trough it did not discharge itself by following the path of least resistance but climbed the steep bank on the further side. How this is to be explained I confess I do not know, and those who are responsible for the postulate have never tried to explain it; but this is not all. The boulders which this ice-sheet is supposed to have carried to Central Germany and to Britain are not angular boulders, such as glaciers carry on their back, but are for the most part rounded or subangular, and according to the Glacial champions were moved along by the ice-sheet under itself in the form of what is called a *moraine profonde* (a thing which is quite incomprehensible to me).

Now, granting the possibility of a *moraine profonde*, as understood and postulated by the Glacial champions, how are we to explain this action of the ice? Ice is not a rigid substance but a viscous one; when a viscous body, in moving along, meets with a deep depression, it does not move down into the hollow and up again on the other side, but it fills up the depression.

Now, granting that a great ice-sheet came down from Sweden towards Germany, dragging along with it and underneath it the postulated *moraine profonde*, when it reached the Baltic trough it would pour down into it and fill it just as water fills a hole in a river bottom, and having filled the hollow it would become embayed in it. The ice coming on behind would then flow over the embayed ice, which would remain as quiescent and unmoved as I believe the water in deep pits in a river bed is; but what about the *moraine profonde* (that unverified postulate of the wilder glacialists)? What would become of it? If, as we are told, an ice-sheet can drag a *moraine profonde*, consisting of loose materials many scores of yards thick, along with it over a rocky bottom, are we further to believe that it could do so over another ice-sheet as long as the Baltic is wide, and thus carry its stony load safely into Germany and Russia? Why, Mr. Maskelyne and all his confrères are nothing to these wonderful wizards, who are responsible for teaching a noble science to the ingenuous youth of the closing years of this century of marvels.

The glacialist apparently argues, however, that the ice would not be embayed in this fashion, but would move on without any difficulty down and up again and right across the great depression, being impelled by the force behind it in some unexplained way, and would carry its *moraine profonde* along with it. This presents another difficulty: if the ice were not embayed, the stones surely would be; they would be caught in the hollow and accumulate in it until that hollow was filled up level with the top of the bank on either side. But the Baltic is not full of stones; it is full of water: hence the dilemma is twofold.

I am bound to be quite candid and to say that a similar difficulty applies to the aqueous distribution of the Scandinavian boulders over the plains of Germany. Water rolling along loaded with stones would inevitably drop its burden into the first ditch it rushed athwart and fill it up, and the Baltic for our present purpose is only a big ditch. How, then, comes it to be filled with water instead of being choked up with drift?

This difficulty compels those among us who do not approve of appealing to causes until we have tested their competency, to try to offer some explanation. The explanation I would offer is, that the history of the Baltic depression has been very generally misunderstood. Instead of being in its present form an old feature in physical geography, one part of it is in fact a recent one, namely, that part which runs east and west to the south of Sweden and to the north of West Prussia and Mecklenburg. I have been satisfied for some time, and I find that the view has been urged in Germany by at least one geologist of repute, that the east-and-west section of the Baltic, together with the Sounds between the Danish islands, are in fact very recent features geologically speaking. It is very probable that when the Drift was distributed they did not exist at all, at all events in the place where we now find them, but that a continuous land surface connected Scania and Denmark with Mecklenburg and Pomerania.

I hope to discuss this issue and the consequences dependent on it on a later occasion. The present paper concludes what I have to say in criticism of the Glacial theory as applied to Norway and Sweden, and until some one tries to answer what I have urged I shall conclude that it is unanswerable, which is not an unsound position for a heretic to take.

III.—THE ORIGIN OF MAMMALS.[1]

By Professor O. C. MARSH, M.A., Ph.D., LL.D., F.G.S.;

THE question as to the origin of mammals is not new, but one of a series of similar nature and difficulty. The origin of Birds, of Reptiles, of Amphibians, and of Fishes really precede it, and offer less difficulties in solution. The answer to each, in my opinion, belongs to the future, and how far it may profitably be sought in the present limited state of our knowledge is a fair question in itself.

Too often in the past, a discussion on the origin of Mammals has seemed a little like the long philosophico-theological controversies in the Middle Ages about the exact position of the soul in the human body. No conclusion was reached, because, for one reason, there were no facts in the case that could settle the question, while the methods of investigation were not adapted to ensure a satisfactory answer. This discussion has been on a much higher plane, and we have had an admirable presentation of one side of the case. I cannot, however, quite agree as to the value of the facts and theories that have been presented, and shall consider the question from another point of view.

The Mammals, as we know them to-day, are classed by themselves, yet contain such diverse groups that it may fairly be regarded an open question whether all have a common origin. The attempt to ascertain whence they came is likely to bring out indications that they may have had several sources of origin, and this, if so, may help to explain the great diversity among them.

It is of course evident that some of the most characteristic features of recent mammals—for example, the hairy covering, the circulatory system, and the milk glands—cannot be used in a comparison with fossil forms. The osseous structure only is now available in the early mammals and other vertebrates, and in this alone points of resemblance must be found if different groups are connected genetically.

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[1] Remarks in the general discussion on the Origin of Mammals at the International Congress of Zoology, Cambridge, England, August 25, 1898.

In considering the relations of reptiles to mammals so far as the fossil forms are concerned, which seems to be the main question now before us, I have only time to speak of the skull, and shall refer to some of its salient features already mentioned in this discussion; namely, the teeth, the squamosal bone, the quadrate, the occipital condyles, and with them the lower jaw. These perhaps may serve as crucial points in distinguishing the skull of a reptile from that of a mammal, even if they fail to indicate a near affinity between them.

The different kinds of teeth seen in the reptiles regarded as mammalian in type I consider of comparatively small importance, for the reason that the same general forms of teeth are to be found, not merely in the reptiles supposed to be nearest to mammals, but also in other groups widely different. In the Crocodiles, for example, the extinct genus *Notosuchus*, recently discovered in Patagonia, has all three kinds of teeth well distinguished. Again, some of the Dinosaurs, especially the genus *Triceratops*, have teeth with two roots, a supposed mammalian character. In some Fishes, also (*Anarrhichas*), three kinds of teeth may be seen. It is more than probable, therefore, that the peculiar resemblance between the teeth of mammals and those of the lower vertebrates is merely one of parallel development, the adaptation being along similar lines, and in no sense an indication of genetic affinity.

The great development of the squamosal bone in Theriodont reptiles is not alone, for somewhat similar proportions are found in some other reptiles,—for example, in the Plesiosaurs, where the squamosal is very large, and wrapped round the quadrate. In some of the Dinosaurs, also (*Torosaurus*), the squamosal has an enormous development, while the quadrate remains of very moderate size.

The quadrate bone, always present in Birds, Reptiles, and the other lower vertebrates, is well known as the suspensorium of the lower jaw, which meets it with a concave articular face. The quadrate, however, appears to be wanting in mammals, or at least has not yet been identified with certainty.

What represents the quadrate bone in mammals, is a vexed question in itself, and some of the best anatomists in the past, Cuvier, Owen, Peters, Huxley, and others, have endeavoured to solve the problem. The tympanic bone, the incus, and the malleus have each in turn been regarded as the remnant of the quadrate, but up to the present time the question has not been settled. It is not improbable that the quadrate may have coalesced with the squamosal.

The occipital condyles of mammals, as well known, are two in number and separated from each other. This is not the case with any true reptile, although the contrary has been asserted. The nearest approach appears to be where there is a single bifid condyle, cordate in shape, with the two lobes meeting below, as in some reptiles and a few birds, but not separate as in mammals and amphibians.

Finally, in all known mammals, recent and extinct, the lower jaw is composed of a single piece, and has a convex condyle meeting the skull by a distinct articulation. All reptiles, even those supposed to be nearest the mammals, have the lower jaw composed of several pieces, and these show distinct sutures between them, a profound difference that must be explained away before an approach can be made between the two classes.

It may fairly be said that the separate elements of the lower jaw, if present, would naturally be looked for in the Mesozoic mammals, and this point I have long had in mind. I may safely say that I have seen nearly every species of Mesozoic mammal hitherto described, and have searched for evidence on this point without success. I have also sought for the separate elements in the young of recent forms, but without finding any indications of them.

Besides the crucial points I have mentioned in the skull, there are others of equal importance in the skeleton, which I must not take time to discuss, but will venture to allude to one of them in passing. I refer to the ankle joint, which, when present, is at the end of the tibia in mammals, and in reptiles between the first and second series of tarsals. When we really find an approach between these two classes, the ankle joint will probably show evidence of it.

Having thus shown, as I believe, that we cannot with our present knowledge expect to find the origin of mammals among the known extinct reptiles, and that in attempting this we are probably off the true line of descent, it remains to indicate another direction in which the quest seems more promising.

Since 1876, when Huxley visited me at New Haven, and we discussed the probable origin of both Birds and Mammals, I have been greatly impressed by his suggestion that the mammals were derived from ancestors with two occipital condyles, and these were doubtless primitive Amphibians. I have since sought diligently for the ancestors of birds among the early reptiles, with, I trust, some measure of success, but this is a simple problem compared with the origin of mammals which we have before us to-day.

In various interviews with Francis Balfour in 1881, at the York Meeting of the British Association, we discussed the same questions, and agreed that the solution could best be reached by the aid of Embryology and Palæontology combined. He offered to take up the young stages of recent forms, and I agreed to study the fossils for other evidence. His untimely death, which occurred soon afterwards, prevented this promised investigation, and natural science still suffers from his loss. Had Balfour lived, he might have given us to-day the solution of the great question before us, and the present discussion would have been unnecessary.

The Birds, like the mammals, have developed certain characters higher than those of reptiles, and thus they seem to approach each other. I doubt, however, if the two classes are connected genetically, unless in a very remote way.

Reptiles, although much lower in rank than birds, resemble mammals in various ways, but this may be only an adaptive likeness. Both of these classes may be made up of complex groups only distantly related. Having both developed along similar lines, they exhibit various points of resemblance that may easily be mistaken for indications of real affinity.

In the Amphibians, especially in the oldest forms, there are hints of a true relationship with both Reptiles and Mammals. It seems to me, therefore, that in some of the minute primitive forms, as old as the Devonian, if not still more ancient, we may yet find the key to the great mystery of the Origin of Mammals.

IV.—PROF. HULL'S "SUBMERGED PLATFORM OF WESTERN EUROPE."

By Prof. J. W. SPENCER, M.A., Ph.D., B.A.Sc., F.G.S.

MR. JUKES-BROWNE'S contribution to this subject, in the September number of the GEOLOGICAL MAGAZINE, brought out a clear reply from Professor Hull in the next issue. Here the argument practically ceased, for in his letter in November Mr. Jukes-Browne turned his correspondence into an academic disputation of the meaning of the word 'escarpment,' for which other expressions could have been used, and the flat denial of the evidence submitted by Professor Hull. This is to be greatly regretted, for Mr. Jukes-Browne does not show evidence to the contrary, nor that he has investigated any of the facts for himself—such as the contouring of the fullest charts with isobars of two hundred or three hundred feet apart—before pronouncing his *ipse dixit.*

Mr. Jukes-Browne challenges the analogy drawn by Professor Hull between the drowned declivities, facing the continental shelf, and the slopes—whether steep, abrupt, or precipitous—which mark the descent from an elevated tableland, plateau, or even lower plain to the country below. Although Professor Hull uses the word 'escarpment' as covering this topographical feature, in exactly the sense commonly understood in America, I purposely avoid its adoption, so as not to allow of the diversion from the phenomena themselves. Mr. Jukes-Browne asks if Professor Hull can point out such a conspicuous declivity from one platform to lower plains "anywhere in Europe which has a length of 700 miles and a height above its base of 7,000 to 8,000 feet." The question appears to imply a negative answer, to be used as a refutation of Professor Hull's inferences. The question should not have been limited to evidence obtainable in Europe, where presumably such a feature is not likely to be found, but should have been extended to any region. With this latitude for reply, the reader may have the opportunity of knowing (as I certainly think Mr. Jukes-Browne has had) that the great face of the Mexican tableland is characterized by an abrupt slope reaching down 6,500 feet to the inner edge of the coastal plain, or over 8,000 feet to the Gulf of Mexico. This slope has a length of several times 700 miles, and extends from Mexico into the United States. In point of magnitude and abruptness, and also of the character of the dissecting valleys, this Mexican slope can quite as well be taken for comparison with Professor Hull's declivities as if found in Europe.

Irrespective of the origin of the tablelands, whether the result of stupendous faultings or of more gentle bulgings of the earth's crust, with the frontal margins fashioned by waves, or by both, or by other causes, the only point for consideration is the fact that the surfaces of these slopes have been moulded by the action of rains and streams, so as to be dissected by great deep valleys crossing all the formations, since they were last elevated above the sea. Besides many large valleys heading abruptly in the tableland, there are numerous short tributaries, called in America by the name of 'amphitheatres,' from two to ten miles long and thousands of feet deep. These begin abruptly in the edge of the high plateaux, and may be likened to gigantic wash-outs, such as are formed by the action of rains upon the soft materials of an elevated coast, and elsewhere. The elevation of the tablelands appears to have been interrupted by pauses allowing for the formation of base-levels of erosion or platforms or steps along the face of the great slopes and in the valleys themselves. Such features upon the edge of the high plateaux show the subaerial sculpturing of the great declivities regardless of the primary origin of the slopes. Then comes the important point that they are an exact representation, upon the surface of the land, of the submarine valleys and amphitheatres dissecting the slopes which descend from the submarine plateaux to the ocean floors. If the form and gradients of the sculptured features of the great terrestrial slopes, whether above or below the sea-level, be carefully studied, they will answer for themselves Mr. Jukes-Browne's remark "how the existence of river-made valleys can possibly prove the declivity to have been made by subaerial agencies passes my [Mr. Jukes-Browne's] comprehension"; for Professor Hull is only considering the formation of such surface features, when found beneath the sea, as evidence of changes of level subsequent to the subaerial sculpturing of the platforms and declivities themselves.

Nor is it alone on the margins of the plateaux overlooking the Gulf of Mexico that perfect topographic features similar to the drowned valleys are to be found. The Grand Cañon of the Colorado is over 200 miles long, and reaches to a breadth of thirteen miles and a depth of over 6,000 feet. It dissects a plateau having a height of over 8,000 feet above the sea. There is no lack of examples confirming the complete resemblances between the erosion features of the bold reliefs of the land and those beneath the surface of the oceans. The problem is one of great magnitude, and the amount of the material available is not small; but the conditions for investigations from the simpler to the more complex forms are more favourable in America than in Europe, and this is no doubt why geomorphic studies have not received the attention they deserve in Europe. The phenomena by which the geomorphist reads the history of the land features seem so simple that some geologists attempt to criticize the long and tedious investigations of physical geologists without having studied the grammar of the investigations. The result is precisely the same as would be the determination of a marine horizon if one had never studied a fossil. Then the results are so remarkable that there is a sort of crime in presenting important facts which had escaped observation until such a recent date. Had Mr. Jukes-Browne carefully examined the data for himself, as Professor Hull has been doing—and it cannot be accomplished without devoting a great deal of time to it—I should be amazed to find him again writing, "I do deny (that the border" —i.e. of the submarine shelf—"can properly be called an escarpment or) that there is any proof of its having been fashioned by subaerial agencies." The parentheses are mine, as only the question of the sculpturing of the abyssal slopes is of any importance. Such a denial (without the accompanying evidence of actual investigation of the question), whether by an individual, or officially by the President, or even the whole council of any learned society, in the presence of the facts obtainable, can only cast reflection upon their discernment and displays a considerable degree of complaisance in denouncing the results of long and careful study in a new field of investigation, though living near that field, to which the critics are strangers. The investigator must have courage to continue in the face of denials by critics and councils, whose criticisms are usually the expressions of one man officially announced, and therefore of little more real value than the harm which they do. Moreover, human nature is the same among geologists as other men, and the announcement of newly interpreted phenomena is often not to be tolerated, except from the officials or critics themselves. It is the more surprising that Mr. Jukes-Browne should desire to deny the great subsidences of the continental margins, as he has been the advocate of the elevation, in the West Indies, from abysmal depths of the sea bottom, demanding a change of level of land and sea quite as great as Professor Hull now claims. His conclusion was based upon palæontological evidence, and beyond this field the objector certainly appears not to have grasped the researches of Professor Hull.

Considerations as to the point of time of the recent great elevations, as shown by Professor Hull, Mr. Jukes-Browne's denial of the elevation (in his last letter) would seem to render superfluous. But it may be added that the evidence in America, at least, indicates the late great changes of land and sea to have been in progress between the later Pliocene days and in the Pleistocene period, but that there is nothing showing the great changes (within that range of time) to have been actually synchronous; for in America, while the east was elevated the west was depressed, and again, while the west was lately being elevated, the east subsided; and so it may have been that the elevation of the two sides of the Atlantic were not simultaneous: but these possible conditions do not modify the more general hypothesis that some time in the early Pleistocene period the continents on both sides of the Atlantic were high.

NOTICES OF MEMOIRS.

I.—Notes on an Expedition to Christmas Island. By C. W. Andrews, B.A., B.Sc., F.G.S., Assistant in the British Museum (Natural History).

[Sir John Murray, having resolved to send a naturalist at his own expense to investigate the fauna and flora and the geology of Christmas Island, invited Mr. C. W. Andrews, of the Geological Department, British Museum (Natural History), to undertake the task. Having obtained the necessary leave of absence Mr. Andrews sailed from England on May 4th, 1897, and after an absence of 15 months he reached home on August 3rd, 1898. He made a considerable stay in Java on his outward passage; he also visited the Cocos-Keeling Islands on his return voyage. The expedition was most successful.

The collections made by Mr. Andrews during his stay on Christmas Island include geological specimens and many illustrating the botany and zoology. These comprise 274 mammals, birds, and reptiles; 183 mollusca; 1,419 insects; and 378 spiders, myriopods, crustacea, echinoderms, and worms. A selection of the specimens have been generously presented by Sir John Murray to the British Museum (Natural History).

The island is typically oceanic, and the mammals, land birds, and many of the insects found are peculiar to it; the geographical and geological observations made by Mr. Andrews are also of great interest.

The following abridged account communicated by the author is from a paper read by him before the Royal Geographical Society, November 28th, 1898.—H. W.]

One of the most interesting of the lonely islets of the Indian Ocean is Christmas Island, which lies about 190 miles south of Java, in lat. 10° 25′, long. 105° 42′. The seas around it are of enormous depth, and soundings of over 1,000 fathoms occur within two or three miles of its coasts. To the north and north-west is Macclear deep, in which 3,200 fathoms were found, and to the south is the more extensive Wharton deep, with upwards of 3,000 fathoms. The island, in fact, rises from the summit of the low submarine ridge which separates these two abysses, and on the westward end of which the Cocos-Keeling Islands are situated.

Seen from the south-west, the island appears as a long green ridge nearly level at the top, there being only slight elevations at the north-west and south-east ends. The ridge descends seaward in a succession of terraces, the upper ones bounded by comparatively gentle slopes, the lower by a high and nearly vertical cliff, below which there is a narrow platform sloping gently down to the sea-cliff. This is usually about 15 to 30 feet high, and is much undercut by the heavy swell that is continually breaking against its base. On approaching nearer it can be seen that the whole island is covered with a dense forest, only broken by the grey face of the high inland cliff which runs round the greater part of the island, rising like a wall above the tall trees growing on the shore terrace.

If the coast be examined in a boat or from the top of the sea-cliff, it will be seen that a submarine terrace in the shape of a fringing reef is being formed round the greater part of the island. It varies greatly in width, and also in its depths below the surface; in some places it is partly dry at low-water, in others some fathoms deep. Outside the edge of this reef the water deepens suddenly.

The greatest length of the island, from North-East Point to Egeria Point, is about 12 miles. The greatest width from north to south is about 9 miles; the least 3½ miles. Its area may be roughly stated at 43 square miles.

The island consists of a central plateau, highest towards the north and east, and descending to the sea on all sides by a succession of terraces, separated by slopes or cliffs. In most places the arrangement of these, from the edge of the plateau downwards, is—(1) a steep slope strewn with blocks; (2) a broad terrace, followed by a similar slope (this seems to be wanting on the south); (3) a second terrace, terminating in a cliff 200 or 300 feet high; (4) the shore terrace, sloping gently down to the sea-cliff; (5) the present fringing reef. There are, however, many local differences, the more important of which will be noticed below.

The Central Plateau.

The edge of the central plateau is roughly parallel to the coast, receding farthest from it opposite the principal headlands. It is highest along its northern and eastern borders, where there is a raised rim, the average height of which above the sea is about 800 feet. Towards the south it slopes away so that its edge is only from 400 to 450 feet high, but there are some slight elevations above this general level. On the west the upper terraces are replaced by a gentle slope, and even the first inland cliff is not well marked except towards North-West and Egeria Points.

Along the raised rim of the plateau there are a number of hills, the highest of which (Murray Hill) occurs towards North-West Point. It is a nearly flat-topped hill, divided by an oblique valley into a larger and rather higher western portion and a lower eastern one; the greatest height is about 1,170 feet. The summit is formed by masses of dolomitic limestone, and on its lower slopes there are beds of shelly limestone, and a peculiar deposit which seems to be mainly made up of tiny spherules of altered volcanic glass. The outer face is very steep, but towards the south the land first descends gently, then rises a little, finally sinking to the general level of the plateau in a long gradual slope. On the south-western side there are occasionally patches of rounded pebbles, which are of a volcanic nature, and are, perhaps, derived from the bed above mentioned. Similar nodules occur in many places on the higher parts of the island.

The next highest hill (Ross Hill) is over South Point. It also has a flat top covered with dolomitic limestone, in which traces of gastropod shells are visible. On its outer side there is a low cliff, and below this a long steep slope covered with blocks of limestone in the wildest confusion, and thickly overgrown with creepers and brushwood. Towards the plateau also the descent is rather abrupt.

Over North-East Point is another elevation (Phosphate Hill), which, though not so high (900 feet), is particularly interesting on account of the extensive deposit of phosphate of lime which is found there. This substance is strewn over the surface in blocks of all sizes, and in some places it is found to a considerable depth; in others, however, it can be seen to rest directly on an irregular surface of dolomitic limestone, occasional pinnacles of which project through it. At the northern end of the hill the phosphate is found on both outer and inner slopes, but farther south on the plateau side only, the outer being occupied by a reef of limestone, which descends to the terrace beneath in a low cliff. The area actually covered by this thick deposit of phosphate of lime is about half a mile long by a quarter broad, but an immense quantity occurs in the form of irregular nodules and blocks scattered over all the slopes and terraces of this part of the island. There are other less extensive beds over Flying Fish Cove, and also at several points along the eastern edge of the plateau. Probably, when the islands were still low and not covered with forest, they formed the homes of myriads of sea birds, and the guano thus formed, after undergoing alteration, mainly through loss of its organic matter, gave rise to the hard phosphatic rock now existing. At the same time the limestones on which it rests have often been phosphatized, and lumps of coral consisting mainly of phosphate of lime are sometimes found. The extensive accumulations of guano which must have taken place point to a time when the rainfall was much less than at the present day, a condition which may, at least in part, have been dependent on the circumstances that the islands were low and probably free from forest.

On the eastern rim, between Phosphate Hill and Ross Hill, there are several smaller elevations, all presenting similar characters, viz.: having on their seaward side a steep talus slope or low cliff, a flat top, and a moderate declivity on the inland side. Between the hills both on the north and east coasts, the rim of the plateau varies a good deal in character. As a rule, its outer edge is marked by a kind of rampart of lines of limestone pinnacles separated by channels, but sometimes it descends by a gentle slope; in either case, beneath the cliff or the slope there is always a steep talus-strewn declivity passing down to the first terrace.

The northern part of the plateau within the elevated rim is particularly characterized by the presence of numerous low hills (about 50 feet), with more or less flat tops covered with blocks and pinnacles of limestone. Further south there are several step-like ridges, running in a generally east-and-west direction; their southern face is covered with blocks of limestone, composed mainly of rather fresh-looking corals. In a few places similar limestones form extensive reefs, out up into deep channels and holes. These reefs, when covered with thick bush, form almost impenetrable obstacles.

The Upper Slopes and Terraces.

As already mentioned, there is beneath the edge of the plateau a steep slope usually covered with talus, but where the rocks composing it are exposed they are found to consist of foraminiferal and coral limestones, and are often full of angular fragments of older limestones. Beneath this slope is a level terrace varying in width from a few yards to a quarter of a mile or more, and bounded on the seaward side by a second steep declivity, or in places by an actual cliff. The rocks comprising it usually show very distinct traces of coral, and sometimes seem to be entirely composed of it. This slope is absent on the southern side of the island.

The next terrace also varies considerably in width; on its outer margin there is usually a broad belt of pinnacles of limestone separated by channels. In the neighbourhood of Steep Point, it rises into a rounded hill covered with blocks of phosphate of lime. This hill must have formed a small islet at the time the foot of the second inland cliff was washed by the sea. In other places there is a channel 40 or 50 yards wide running parallel to the edge of the cliff; the inner side is formed by a cliff 30 or 40 feet high, the outer by walls and pinnacles separated by branching channels, the floor of which, like that of the main channel, is perfectly level. Towards the sea there is a steep slope covered with blocks of limestone. When the sea was 350 to 400 feet higher than at present, this channel formed a sort of canal in the reef parallel to the coast.

Beneath the terrace just described comes the first inland cliff, by far the most conspicuous feature of the island. Usually it has a vertical, or nearly vertical, face, and it is especially well-marked at the headlands. Its summit is from 250 to 300 feet above the sea. In several places about 150 feet above the shore platform there are distinct traces of wave action, the most notable being the presence of caves along this line. In some cases beneath this point, instead of a vertical face, we find a steep slope of limestone with coral in position of growth, apparently the remains of a narrow fringing reef, founded upon and partly composed of talus. That the elevation of this cliff has been of an intermittent character is further shown by the fact that where the slopes of the island are gentle and no high cliff has been formed, there is either a succession of minor cliffs separated by terraces and partly built up of coral rock, or merely a slope with ledges of coral limestone. Although these minor cliffs and ledges may be continuous for some distance in any given locality, they do not always correspond to those found a few miles off. It must also be noted that the geological structure and even the origin of this cliff are not everywhere the same, a point that will be referred to more fully below.

The shore terrace slopes gently down from the foot of the first inland cliff to the sea-cliff, which is from 15 to 30 or more feet high, and is often undercut by the waves to a remarkable extent, so that it sometimes overhangs more than 20 feet. The inland side of this terrace is often covered with pinnacles of rock similar to that of the cliff above, and once formed part of the foreshore planed down by the waves. Near the sea the terrace is clearly a raised fringing reef resting on a foundation of talus; the corals are often very fresh in appearance. In some localities this platform has been cut into the older rocks (orbitoidal limestones, basalts, etc.) which form the basis of the island, and in such places small streams may occur, the water being held up by the volcanic rocks. The point where these are best developed is on the east coast, where there are two or three muddy brooks and a small fall of excellent water, which gushes out over a bed of basalt just above high-water mark.

On the south, where the cliffs are exposed to the full force of the swell produced by the south-east trade wind, which blows most of the year, the coast scenery is very fine. The cliffs are cut into numberless narrow inlets, and their summits are often completely bare of vegetation for some distance from the sea. Blowholes are very numerous, and several columns of spray rising high above the trees may often be seen at once.

At various points round the coast there are shingle beaches. The most important of these are that in Flying Fish Cove and West White Beach, at both of which landing is fairly easy. There are also two or three others on the north coast, several on the east, and one or two towards the northern part of the west coast; most of these are small and shut in by cliff, and are covered at high-water.

The above is a brief account of the usual plan of the island, but there are several localities in which considerable divergences from this occur. One of these is Steep Point, where a deep fissure, forming a narrow valley, has cut off an angle of the first inland cliff, and the portion thus isolated has tilted forward so that the usual shore platform, if it ever existed, has been carried beneath the sea, and the headland, which is 150 to 200 feet high, is, in fact, part of the first inland cliff.

Again, on the east coast, near North-East Point, extensive slips or faults have taken place, the result being that the ordinary terraces are replaced by a single precipice 500 to 600 feet high, the foot of which is covered by talus of enormous blocks of limestone. In this case the edge of the island as far back as the second inland cliff has slipped down beneath the sea, and has helped to build up the foundation upon which the reefs now forming the shore terrace were built. Nearer North-East Point the slip was less extensive, and the slipped mass here forms the first inland cliff, on the top of which there are several step-like ridges running parallel to its edge, and marking minor dislocations. The rock comprising both this cliff and the precipice further south seems to be almost wholly a mass of orbitoidal limestone, the flat joint faces of which give it a very characteristic appearance; the cliff on the southern side of Egeria promontory is similar, and the small cliffs resulting from successive steps can be plainly seen.

At the western end of the island the upper cliffs are replaced by gentle slopes, and even the first inland cliff is ill defined, except towards North-West and Egeria Points. Another characteristic feature of this region is the occurrence of several valleys running down to the sea in a generally south-western direction. These first commence as a shallow depression at about 400 feet, but, as they are followed, deepen to a narrow gorge which cuts through the first inland and sometimes the sea cliff also. The scenery of these valleys is the most picturesque on the island, and reminds one a little of the dales in the Mountain Limestone in the Peak District. The floor of these valleys is generally formed of volcanic rock (basalt), and in the wet season is occupied by a small stream, which descends to the sea by a succession of falls and rapids; but at the time of my visit water was only found in the northernmost valley.

The last locality to be described is Flying Fish Cove, by far the most important, because it seems to supply the key to the structure of the island as a whole. In the large-scale map of this district given, it will be observed that at this point the sea-cliff is interrupted, and its place taken by a long curved stretch of white shingle beach, in front of which a broad fringing reef stretches from one end of the cove to the other. Behind the beach is a nearly level platform, composed mainly of blocks and fragments of coral mingled with talus from the cliff above. This level has been, for the most part, cleared and planted with cocoanut-palms, fruit-trees, and vegetables, and is the site of "Clunies-Ross Settlement," which consists of some nine or ten houses, workshops, and stores. The cliff joining the back of the cove is about 500 feet high in the middle, but decreases in height towards the ends, and towards the north the slope becomes less steep. For the greater part of its length it consists of alternations of low, more or less vertical cliffs, with steep talus slopes; but towards the southern end the upper part forms overhanging precipices of 200 feet or more in height, while the lower portion is covered by a talus slope of limestone blocks, often as large as a fair-sized cottage. Some of these lie far out on the reef. In this cliff and in its immediate neighbourhood we have almost the only section from which it is possible to get an idea of the nature of the foundation upon which the upper reefs have been established; almost everywhere else the central portion of the island is concealed by the investing covering of more recent limestones which have formed round the island, either as sediment derived from the higher coral masses or as reefs which have grown on the slopes of the island during its elevation. The circumstance that nearly all the rocks of the island are white limestones, often largely made up of fragments of older beds or containing fossils derived from them, renders the interpretation of the facts observed a matter of great difficulty. It will not be necessary, however, here to enter into details of the geology of the island, and only a brief sketch of the structure of the neighbourhood of Flying Fish Cove is given.

Round the greater part of the cove, about half-way up the cliff, there is a thick bed of yellow foraminiferal limestone, the nearly vertical face of which is from 15 to 60 feet high. Beneath this, and apparently penetrating its lower surface, are several masses of volcanic rock, mainly basaltic. Above the limestone is another bed of basalt, upon which there are thick bands of palagonite tuffs, and occasionally traces of basalt above these again; but the upper slopes are so thickly covered with soil and fallen blocks of limestone, that it is difficult to determine the exact structure of this part of the cliff. About the middle of the cove the hard limestone is found at a rather higher level, apparently the result of faulting. but its relations to the volcanic series are the same. Southward of this the bed dips downward towards the shore, and the basalt and tuffs resting upon it disappear abruptly, their edges being overlapped by hard white limestone with *Orbitoides.* This rock forms the upper 50 feet or so of the cliff throughout its length, and on the summit occurs in low cliffs, ridges, and pinnacles. At the southern end of the cove it thickens out to a cliff some 250 to 300 feet high, the lower part of which is penetrated by masses of basalt. Above the cliff to the southward this limestone is found on the eastern and western sides of a broad belt of basalt, which forms a series of rounded hills with valleys opening towards the sea. On the eastern side its base is about 500 feet above the sea; on the west, where it is largely concealed by the more recent deposits forming the cliffs and terraces representing the first inland cliff, it is only 300 to 350 feet. No doubt this limestone completely covered the basalt, but has been removed by denudation; and, in fact, further south the volcanic rock is completely concealed by limestones.

Further inland, above the orbitoidal limestones comes the steep slope of the second inland cliff, which is here largely composed of corals; shells of mollusca are also found, and there are some beds of foraminiferal limestone without *Orbitoides.* Above this cliff is a long slope with lines of limestone pinnacles parallel to its edge, and above this, again, the upper inland cliff, or rather slope. Along the foot of this there are some ridges of coral limestone; but towards the summit it rises into rounded hills of dolomitic limestone, with a great many blocks of phosphate of lime here and there. These piles are probably the remains of islets along the edge of the lagoon (now the plateau) before the first elevation of the island took place.

The history of the island, as far as it can be made out, seems to have been as follows:—At first, at no great depth, there was a submarine bank upon which numerous foraminifera, including *Orbitoides,* lived, and the shells of which formed thick beds of limestone. The foundation of this bank was volcanic, and from time to time lava was erupted through and upon the limestones: the occurrence of thick bands of palagonite tuff indicate that the eruptions were submarine. Some elevation took place, and the beds of tuff became consolidated by the infiltration of lime. In the next place, the whole was covered with thick beds of white limestone crowded with large *Orbitoides.* These strata seem to have overlapped the edges of the beds of tuff, and in places it can be seen that they dip away from the central mass. The deposits resting on the orbitoidal limestones are for the most part covered with recent accumulations, but they appear to have been mainly foraminiferal limestones.

Upon the foundation thus prepared extensive reefs grew up and formed an atoll-shaped group of islands, the reef flat and islands being now represented by the raised rim of the plateau and the hills rising from it, the lagoon by the central plateau itself. The rounded hills and lofty pinnacles found within the raised margin are probably the remains of knolls and masses of coral growing up in the lagoon, such as may be seen in the Cocos-Keeling Islands at the present day. The height of the hills over North-West and South Points may be accounted for by supposing either that they are points of local elevation greater than that affecting the main mass of the island, or that they represent the higher parts of the bank, upon which reefs were formed before the greater part of it was near enough to the surface for the growth of reef corals. During the formation of these higher reefs, the material derived from their wear, mingled with the remains of organisms living around the coast, formed thick deposits of limestone upon the flanks of the island.

The first important movement which took place seems to have resulted in the elevation of the northern and eastern sides of the island, the south and west probably remaining submerged. At this time the reefs forming the second inland cliff grew round the north and east coast, and probably some of the ridges of coral limestone running across the middle of the island were formed near the new shore-line on the side of the lagoon.

The next extensive elevation affected the whole area equally, and along the new shore-line the second inland cliff was cut back into the reefs just formed, or even in some places into the central foraminiferal limestones. Subsequently a series of movements of elevation led to the formation of the first inland cliff, or, on the more gentle slopes, to the succession of small cliffs and ridges of coral rock which represent it.

During these various movements much slipping and faulting took place round the island; the effects of this at Steep Point and North-East Point have already been described. As a result of this, and of the action of the waves around the coast, a submarine talus slope was formed. upon which a fringing reef was established, and at the next elevation this was converted into the shore terrace, while its margins were cut back into the present sea-cliff. Finally, as already mentioned, a reef is now growing around the coast which some day may form yet another raised terrace round the island. It is a point of some interest that Mr. Andrew Ross, during the eight or nine years he has been residing on the island, has noted the occurrence of two slight earthquakes, the more severe occurring in October, 1895; this was followed by heavy falls of rock from the cliffs.

II.—Structure of a Coral Reef.—Report of the Committee, consisting of Professor T. G. Bonney (Chairman), Professor W. J. Sollas (Secretary), Sir Archibald Geikie, Professors J. W. Judd, C. Lapworth, A. C. Haddon, Boyd Dawkins, G. H. Darwin, S. J. Hickson, and Anderson Stuart, Admiral Sir W. J. L. Wharton, Dr. H. Hicks, Sir J. Murray, Drs. W. T. Blanford, C. Le Neve Foster, and H. B. Guppy, Messrs. F. Darwin, H. O. Forbes, G. C. Bourne, and J. W. Gregory, Sir A. R. Binnie, and Mr. J. C. Hawkshaw, appointed to consider a project for investigating a Coral Reef by boring and sounding.

THE boring into the coral reef at Funa Futi, under the superintendence of Professor Edgeworth David, was carried down to a depth of 643 feet. After he had quitted the island to return to Sydney the work was continued until, owing to a breakdown of the apparatus, it finally ceased at a depth just short of 700 feet. The cores obtained during the work have been forwarded to England, and are now being worked out under the supervision of Professor Judd in the laboratory of the Royal College of Science at South Kensington. A brief summary of the results down to 643 feet was presented to the Royal Society on November 25, 1897, and will be found in their "Proceedings." According to the survey of Funa Futi and the neighbouring seas made by Captain Field, of H.M.S. "Penguin," it appears that the shape of the former is that of a cone with a rudely elliptical base rising with a gradual slope from the ocean floor at a depth of about 2,000 fathoms, and forming a kind of mural escarpment for the last 750 feet (approximate). When the whole party had returned to Sydney, Professors David and Stuart, after discussing the question of renewing the attempt to pierce the reef, the bottom of which, from the change of slope mentioned above, they thought must lie within 800 feet of the surface, prevailed on the authorities of the Department of Mines, Sydney, to lend plant and workmen in order to continue the old borehole, and, if possible, to put down another one in a shallow part of the lagoon. Application was made to the Admiralty by the Royal Society, and permission was given for the members of the expedition and the plant to be conveyed from Suva to Funa Futi and back by H.M.S. "Porpoise." The expedition has been at work during the summer, and intelligence of the result will doubtless have reached England during the autumn. Until this arrives, and the study of the materials already in this country has been completed, it would be premature to express any opinion of the theoretical bearing of the results obtained by the very successful operation undertaken in 1897.

III. — THE FOSSIL PHYLLOPODA OF THE PALÆOZOIC ROCKS. Fourteenth Report of the Committee, consisting of Prof. T. WILTSHIRE (Chairman), Dr. H. WOODWARD, and Prof. T. RUPERT JONES (Secretary). (Drawn up by Prof. T. RUPERT JONES.)[1]

§ I. In our First Report on the Palæozoic Phyllopoda (presented to the Association in 1883) the genus *Dithyrocaris* was included in the Tabular List at p. 216 of the Reports for 1883 (1884), as being "ridged along the back (like *Apus*)," and as "being ridged and sometimes prickled." It was referred to as occurring in Carboniferous and Devonian strata.

In the Fifth Report (made in 1887), at pp. 63–66, we enumerated all the known and reputed species of the genus. Thanks to the obliging courtesy of friends and correspondents, we are now enabled to state that we can distinguish the following species found in the British Islands and elsewhere:—

		Scotland.	Ireland.	England.	Belgium.	Germany.	Canada.	U.S.A.
CARBONIFEROUS.								
Carapaces.	1. *Dithyrocaris glabra*, H. Woodward & R. Etheridge, jun.	*						
	2. ,, *ovalis*, W. & E. ...	*						
	3. ,, *granulata*, W. & E.	*						
	4. ,, *testudinea*, Scouler ...	*		*				
	5. ,, *Scouleri*, M'Coy ...	*	*					
	6. ,, *funiculata*, sp. nov. ...	*	*					
	7. ,, *Colei*, Portlock ...	*	*					
	8. ,, *tricornis*, Scouler ...	*		*				
	9. ,, *orbicularis*, Portlock		*					
	10. ,, *tenuistriata*, M'Coy...		*	*	*			
	11. ,, *Youngii*, sp. nov. ...	*						
	12. ,, *striata*, Woodward...	*						
Tailpieces.	13. ,, *lateralis*, M'Coy ...	*		*				
	14. ,, *Neilsoni*, sp. nov. ...	*						
	15. ,, *Dunnii*, sp. nov. ...	*		*				
	16. ,, *carbonaria*, Meek & Worthen							*
	17. *Rhachura venosa*, Scudder							*
DEVONIAN.								
Carapace.	18. *Dithyrocaris Belli*, Woodward...						*	
Tailpieces.	19. ,, *Kochi*, Ludwig... ...					*		
	20. ,, *breviaculeata*, Ludwig					*		
	21. ,, (?) *Jaschei*, Römer ...					*		
	22. ,, *Kayseri*, Clarke ...					*		
	23. *Mesothyra Oceani*, Hall & Clarke...							*
	24. ,, *Neptuni*, Hall							*
CARBONIFEROUS.								
	Gastric Teeth	*	*	*				

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[1] Being a paper read before the British Association for the Advancement of Science, Section C (Geology), Bristol, September, 1898.

Dithyrocaris has a clypeiform test; at all events most of the specimens have a shield-like test, readily dividing into two moieties or valves; but some specimens seem to support the idea of having been able to fold the two sides together. The moieties are often separate, and some are too convex to have formed a quite flat shield; some have the lateral edges turned sharply downwards and inwards.

The valves, or two lateral moieties, were united along their dorsal edges simply: several specimens, however, had a dorsal rugose ridge-plate, over-riding, narrow, and longitudinal (somewhat like that described as an intervening plate in *Mesothyra* by Hall and Clark in 1888), ending in a posterior spine.

The valves are sub-oblong, straight along the middle two-thirds of the dorsal border, and elliptically curved ventrally; more or less rounded at the ends, with a median hollow or notch at their junction on the front and hind borders. The antero-dorsal region ends with a blunt angle or a short process; and the postero-ventral with a strong, sharp, trigonal spine.

The straight hinge-line is defined by two small dorsal notches. The ventral border has a striated, serrated, or fringed margin, either on its posterior moiety or throughout its extent.

The surface of each valve bears one longitudinal (*meso-lateral*) ridge, and sometimes others parallel; also short ridges (*cephalic*) over the gastric apparatus, and slighter ridges (*nuchal*) near the top of the dorsal ridge, all more or less rugose.

Scattered granulations and tubercles are often present on some parts of the valves, also lines and reticulations.

Granulation is feeble and sparse on *D. glabra* and *D. ovalis*; strong and abundant on *D. granulata*. Small prickles, rising from the meshes of a reticulation, are scattered over *D. tricornis*, *D. Colei*, and *D. orbicularis* (?). A system of oblique transverse lines characterizes *D. testudinea*. A feeble reticulation is traceable on *D. funiculata* and *D. Scouleri* (?). Longitudinal striæ mark the surface in *D. Belli* and *D. striata*; and *D. tenuistriata* and *D. Youngii* have longitudinal costulæ.

In consideration of certain differences in the carapaces, we separate Nos. 10 and 11 of the Table, at p. 28, from *Dithyrocaris*, as *Chænocaris tenuistriata* and *Ch. Youngii*, the carapace being bivalved and *gaping*. There is also an obscure Devonian form, from Saalfeld, to which we refer as *Chænocaris Richteriana*. We regard No. 12 as having a *closed* bivalved test, and therefore designate it as *Calyptocaris striata*.

We have had the opportunity of studying an old Apus-like fossil[1] labelled 'Burdiehouse.' It shows a small circular carapace (measuring 15 by 13 mm.), with strong postero-ventral angles, and distinct meso-lateral ridges leading to them; also a slightly curved depression in the middle of the front border, and a granulated margin throughout.

Mr. E. J. Garwood, F.G.S., who is a member of the British Association Committee for defining the zones in the Carboniferous rocks, has just now forwarded for examination a very interesting collection of the remains of *Dithyrocaris*[1] from excavations in the shales of the Millstone-grit series at Eccup, Yorkshire.

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[1] *Hibbertia orbicularis.*

§ II. In the "Proc. United States National Museum," vol. xix (1897), Mr. C. Schuchart has a paper "On the Fossil Phyllopod Genera *Dipeltis* [Packard *emend.*] and *Protocaris*." The latter was noticed in our Report to the Association for 1889, p. 64, and in our Ninth Report (for 1891), p. 300. The original genus *Dipeltis* was established by A. S. Packard, in the "Memoirs of the National Academy of Sciences," vol. iii (1885), Mem. xvi, p. 145, pl. v, figs. 2, 2*a*, as one of the Carboniferous Xiphosura of North America. In the December number of "Natural Science," 1897 (vol. xi, p. 401, figs. 2–5), in his paper on "Fossil Apodidæ," Mr. H. M. Bernard follows Mr. Schuchart in regarding the *Dipeltis*, as defined by the latter, as a Phyllopodous Apus-larva. Mr. C. J. Gahan, however, in "Natural Science," January, 1898, pp. 42–44, points out that it is really a larval form of the Blattarian insect *Etoblattina*, described and figured by H. Woodward in the GEOLOGICAL MAGAZINE, 1887, p. 433, Pl. XII.

§ III. With reference to the Bohemian *Estheriæ* mentioned at p. 4 of our Report for 1893 (Tenth, 1894), Dr. Anton Fritsch has informed us that they were named by him in the "Sitzungsb. k. böhm. Gesellsch. Wissen.," 1894: No. 1 being *Estheria triangularis*, Fr.; No. 2, *E. cyenea*, Fr.; No. 3 [and No. 4?], *E. palæoniscorum*, Fr.; and No. 5, *E. calcarea*.

IV.—THE COMPARATIVE ACTIONS OF SUBAËRIAL AND SUBMARINE AGENTS IN ROCK DECOMPOSITION. By THOMAS H. HOLLAND, A.R.C.S., F.G.S., Geological Survey of India.[2]

IN Europe nearly all crystalline and igneous rocks of any considerable age show signs of hydrous decomposition, which by the microscope can generally be traced far beyond the limits of the very evident superficial crust of weathered products: in some cases, like the peridotites, the changes due to hydration, even in rocks of Tertiary age, have resulted in a practically complete alteration of the original constituents. In working over various parts of Peninsular India, the writer has been struck by an almost constant absence of any but the most superficial traces of hydration, even in minerals like olivine and nepheline, which are so noticeably susceptible to the action of water. As in all tropical and moist climates, however, a complete and rapid superficial decomposition is shown by most of the rocks, and in some areas they are found to be changed into a ferruginous clay, which, though forty or fifty feet thick, is found to retain the characteristic macroscopic structures of the original rocks. In some districts, where the atmosphere is always warm, and during the monsoon season highly charged with moisture without great precipitation of rain, the rocks are similarly decomposed at the surface, but, on account of the limited amount of running water, the lime is retained in the decomposition products, and forms a concretionary 'kankar.'

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[1] For which we propose a new species, *D. insignis*.

[2] Read before Section C (Geology), British Association, Bristol, 1898.

In all these cases, however, although the action of the atmosphere is so striking, the results are purely superficial, and a specimen of rock taken from within a few inches of the clay products seldom shows a trace of hydrous decomposition, even in thin sections under the microscope. This is just as true for such delicate minerals as olivine and nepheline as for the commoner silicates. In many of the basic dykes, certainly pre-Cretaceous and probably Lower Palæozoic in age, the absence of serpentine is so complete that unusual precautions are often necessary for the determination of the olivine, whilst in the numerous occurrences of dunite throughout the Madras Presidency serpentine is extremely scarce. In a nepheline syenite recently discovered in the Coimbatore District, and at least of Cuddapah age, the nepheline on microscopic examination shows mere traces of alteration along the fracture cracks.

In the light of European experience, where most of our petrographical data have been established, the peculiarities of the Madras rocks call for some special consideration, and the object of this paper is to suggest that the probable explanation of the peculiarities now referred to arises from a contrast of the geological histories of the two areas. In Europe all, or nearly all, the rocks have been submerged below the sea during the later geological periods; in South India there is no evidence beyond the immediate precincts of the coastline of any depression below sea-level since Cuddapah (probably Lower Palæozoic) times. In Europe, therefore, the features generally attributed to weathering are the compound effect of submarine and subaërial action; in South India the former class of agencies has not affected the rocks now exposed, and the remarkable freedom from hydration which they show suggest that the action of the atmospheric agencies is purely superficial.

Taking into consideration the presence of lime carbonate and other salts, with a larger proportion of carbonic acid and the great pressure under which sea-water attacks a submerged rock-mass, it is theoretically to be expected that submarine agencies are more potent means of decomposition than those of the atmosphere; but these South Indian observations tend to show that serpentine and other forms of hydrated products within rock-masses are due only in a very limited degree to true weathering.

The products of atmospheric action are removed from the rock surface as fast as they are formed, and deeper portions are *pari passu* brought to the surface. It is not improbable that it is on account of this denudation, which has proceeded without known interruption for so many geological ages, that relatively deep-seated portions of the earth's crust have been brought to the surface in Madras, and that the crystalline rocks there met with at times present peculiarities for which European experience hardly prepares us.

REVIEWS.

I.—WACHSMUTH AND SPRINGER'S MONOGRAPH ON CRINOIDS.[1]

FIFTH NOTICE.

"THE Anal plates," say Messrs. Wachsmuth and Springer, on p. 124, "bear a most important part in the phylogeny of Palæozoic Crinoids, and are also of high importance in respect to classification." This admission necessitates careful inquiry into the homologies of those plates. The views of our authors "have undergone considerable modification"; but the discussion need not be complicated by allusion to earlier publications, however great their quondam value, except when they have been cited as evidence in the present Monograph.

The term 'anal plates' (*analia*) is now restricted by Wachsmuth and Springer to such plates of the posterior interradius as (1) "are directly or indirectly connected with the anus," (2) "take part in the dorsal cup; the others being plates of the anal tube" (tube-plates). The first restriction forbids the application of the term to such of the posterior interradials as are serially homologous with those in other interradii of the individual; it is practicable and natural. The second restriction merely evades one difficulty and creates another. For instance, in such a Camerate genus as *Glyptocrinus* (Fig. 1), the plates of the cup proper merge so gradually into those of the tube proper that no two observers would agree upon the line to be drawn between them in any one specimen; further, owing to the gradual growth of interbrachials, plates that are free tube-plates in the young become fixed cup-plates in the adult, just as free brachials become fixed. Again, in such Inadunate genera as *Delocrinus*[2] (Fig. 9) and *Ulocrinus* (Fig. 3), it is hard to see, from

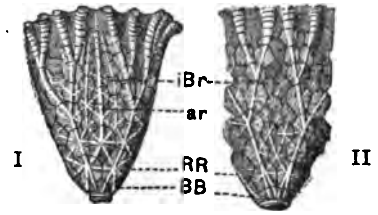

FIG. 1.—*Glyptocrinus decadactylus.* I. From posterior interradius (after W. and Sp.), showing *ar*, the anal ridge, dividing the interbrachials, iBr. II. Another interradius, for comparison (after Meek).

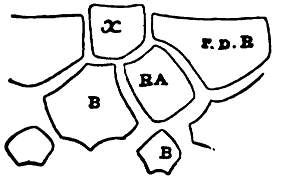

FIG. 2.—Anal area of '*Ulocrinus*' *Blairi* (based on Miller & Gurley's figure). This is not *Ulocrinus*, but represents a stage between *Eupachycrinus* and *Ulocrinus*. It strongly supports the homology here adopted for the anals of *Ulocrinus*.

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[1] The North American Crinoidea Camerata. By C. Wachsmuth and F. Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897.) For First, Second, Third, and Fourth Notices, see GEOL. MAG. for June, July, September, and November, 1898.

[2] *Miller* and Gurley, 1890 = *Ceriocrinus* White pars, 1880, non Desor, 1845, nec *König in tabb. ineditis.*

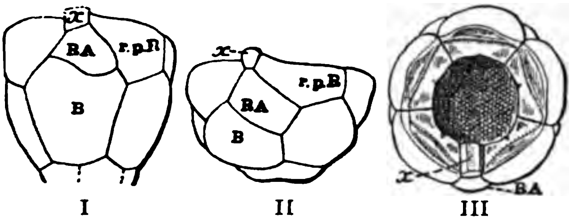

Fig. 3.—*Ulocrinus* (diagrammatized from Miller & Gurley ; × $\frac{2}{3}$).
I. Posterior view of cup of *U. Buttsi*. Note that *x* is not so far removed from post. B. as in II, *U. kansasensis*, posterior view. III. The same seen from above, showing the upper surface of *x*, which must have supported tube-plates.

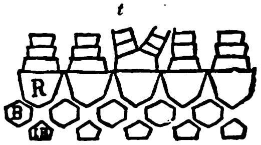

Fig. 4.—*Merocrinus*.

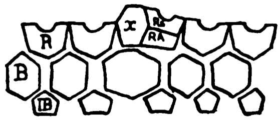

Fig. 7.—*Homocrinus*.

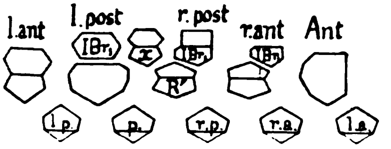

Fig. 5.—*Heterocrinus bellevillensis*.
(Outline after W. & Sp.)

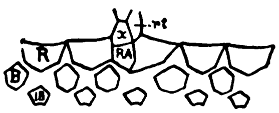

Fig. 8.—*Zeacrinus*.

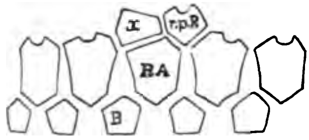

Fig. 6.—*Hybocrinus*.
(Outline after W. & Sp.)

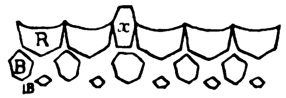

Fig. 9.—*Delocrinus* (= *Ceriocrinus*, White).

In all these analyses (Figs. 4-9) the orientation is that of Fig. 5. The plate *x* of Figs. 3, 5, and 6 is called *t* by W. & Sp. In Fig. 4, *t* denotes the anal tube.

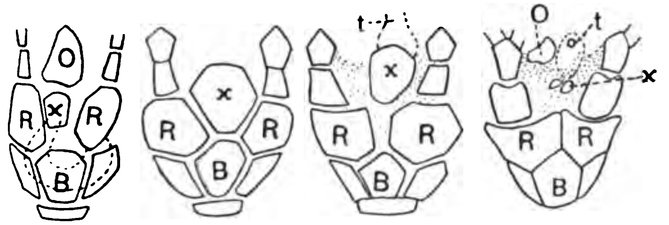

Fig. 10.—Migration of the anal in *Antedon* (after W. B. Carpenter & M. Sars). Originating between the radials, the plate *x* gradually moves upwards, eventually atrophying till only two small fragments remain at the base of the anal tube (*t*). The dotted lines in the left-hand figure show the course of the gut.

Wachsmuth and Springer's own diagrams 16 and 17 on p. 131, and still more from specimens of various species, why a plate, here marked *x*, occupying almost exactly the same position with regard to the radials, should be called 'anal' in the former and 'tube-plate' in the latter; or why the plates marked *t* in their diagrams of *Hybocrinus* (8; *x* in our Fig. 6) and *Poteriocrinus* (15; *rt* in our Fig. 14) should not be held to form part of the cup, since they abut by their sides on plates that are admittedly cup-plates. Moreover, according to this definition, the posterior interradial of the larval *Antedon* is an 'anal' so long as it lies between the radials, but a 'tube-plate' so soon as it passes above them (Fig. 10). Position, then, affords no practicable or consistent guide. But the proximal tube-plates rarely possess any other feature not shared by the fixed anals. Therefore the distinction between 'anals' and 'tube-plates' rests on no morphological foundation, and the terms, though convenient for general descriptive purposes, are out of place in an argument as to homologies. And yet, as will be seen, it is for the purpose of such an argument that the imaginary distinction has been emphasized.

Anals appear in the cup in response to the need for widening the posterior interradius so as to allow room for the rectum internally, and so as to support the anal tube in which the rectum is prolonged externally. We can conceive four ways in which this widening may be effected: (1) by simple widening of plates already in existence, as in Platycrinidæ; (2) by splitting or duplication of plates, as the proximal interbrachial of Actinocrinidæ, which is represented by two plates in the posterior interradius: (3) by intercalation of a fresh plate or line of plates, unrepresented in the other interradii, as, possibly, the large anal by which Hexacrinidæ are distinguished from Platycrinidæ, and the vertical row of anals in Batocrinidæ and Dimerocrinidæ (=Thysanocrinidæ, W. & Sp.); (4) by the lateral displacement or partial atrophy of adjacent radials, permitting other elements to support the tube, as in *Hybocrinus*, where the right posterior superradial is pushed aside and the proximal plate of the tube rests on the enlarged r. post. inferradial, which thus becomes a 'radianal' (Fig. 6).

Now there is no difficulty in any of these conceptions. The examples just quoted are taken from the present Monograph, and probably would be accepted by anyone competent to judge. The difficulty lies in the application to certain cases, notably to the anal area of the Inadunata. Nearly the whole of the sixteen pages on the anal plates is devoted to a discussion of their evolution in that group.

Most of the Inadunata, especially those with a large anal tube or sac, as well as many of the Flexibilia Impinnata (=Ichthyocrinoidea), possess in the anal area of the cup from one to four plates. These are not introduced at haphazard, but bear to one another and to the other cup-plates a definite relation. What the precise relation is, though agreed upon in some cases, remains an open question in others. The fullest development is seen in *Poteriocrinus* and the immediately allied genera (Fig. 14). Here the anals in

contact with cup-plates are four in number: a plate (*x*) resting on the truncate upper margin of the posterior basal; a plate (RA) resting between the posterior and right posterior basals, abutting against *x* on the left and the right posterior radial on the right, and

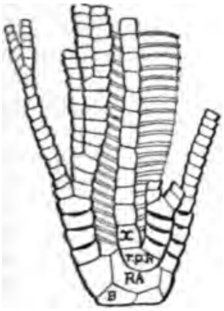

Fig. 11.—*Iocrinus subcrassus.* (Outline after W. & Sp.)

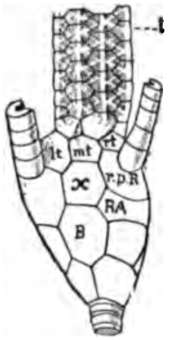

Fig. 12.—*Dendrocrinus longidactylus.* (After J. Hall.)

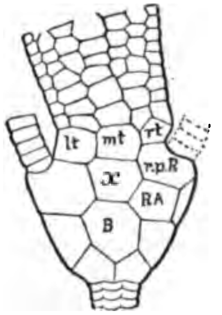

Fig. 13.—*Dendrocrinus Casei.* (Diagrammatized from W. & Sp.)

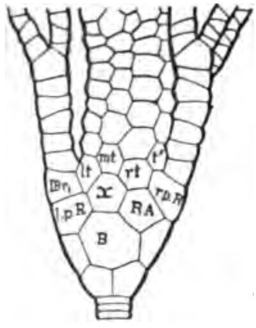

Fig. 14.—*Poteriocrinus* (*Scaphiocrinus*) *elegans.* (After W. & Sp.)

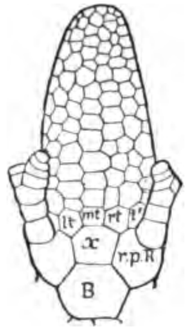

Fig. 15.—*Cyathocrinus longimanus*, anal area. (Diagrammatized from Angelin by W. & Sp.)

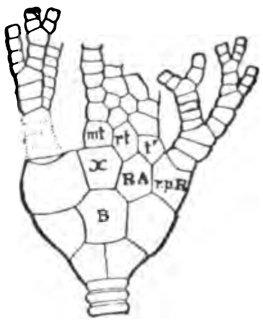

Fig. 16.—*Parisocrinus.* (From MS. drawing lent me by Wachsmuth.)

supporting by its upper margin a tube-plate; this latter (*rt*) rests between *x* and r. post. R, and is followed by a vertical series of similar plates; on the left of *x*, and resting on l. post. R, is a rather smaller tube-plate (*lt*), also supporting a vertical series; *x* itself supports a median vertical series, of which the proximal plate may be distinguished as *mt*.

As to the homologies of these plates, all are now agreed that RA represents the right posterior inferradial, and my name for it, 'radianal,' has won general adoption. This plate, as Wachsmuth and Springer rightly insist, is always found to alternate with the underlying basals; in the early stages of phylogeny it supported a superradial of equal width, but that became squeezed to the right as the anal *plates developed: compare Heterocrinus* (Fig. 5) and

Dendrocrinus (Figs. 12 and 13). Thus RA altered in outline, and was brought into contact with other anal plates; first with *x* (as in *Dendrocrinus* and *Homocrinus*, Fig. 7), then also with *rt* (as in *Poteriocrinus* and allies, Fig. 14), while it might even support a third plate to the right of *rt*, as in some species of *Parisocrinus* (Fig. 16). In some later genera, such as *Zeacrinus* (Fig. 8), RA increased in size and *rt* was again raised above the level of the cup; while in *Ulocrinus* (Fig. 3) the plate *x* also was (to use Wachsmuth and Springer's expression) "crowded out by the large radianal." In other genera, however, RA became reduced and finally disappeared (e.g. *Delocrinus*, Fig. 9).

To turn to *rt*, the plate which in *Poteriocrinus* (Fig. 14), *Atelestocrinus*, and similar forms rests between *x* and r.post.R and on RA, and therefore in the limits of the cup: it is admitted that this is subsequently pushed up out of the cup (e.g. *Zeacrinus* and *Ulocrinus*, Figs. 8 and 3); further, that it was at an earlier stage resting on the left shoulder of r. post. R*s* (e.g. *Dendrocrinus* and *Homocrinus*, Figs. 12, 13, and 7). To this extent I am in full accord with Messrs. Wachsmuth and Springer, and would point out that this admission stultifies their distinction between anals and tube-plates, and allows that a tube-plate can sink down into the cup.

In *Heterocrinus* (Figs. 5 and 17) and *Ectenocrinus* a single plate at the base of the tube rests on the shoulders of the two posterior radials, which are here not separated by any anal plate. This proximal single plate is considered by Wachsmuth and Springer to "take practically the place of the three plates [*lt*, *rt*, and *mt*] in *Dendrocrinus*." They also homologize it with the proximal tube-plate of *Hybocrinus*, which they say on pp. 129, 130, 133 has a similar position. This is a peculiar slip, for their own figure shows that this plate in *Hybocrinus* lies between the posterior radials on a large radianal (Fig. 6). They also homologize with this the proximal tube-plate of *Iocrinus* (p. 130) and apparently *Merocrinus* (p. 128); but this plate rests only on the right posterior superradial, absolutely outside the cup, and is removed by the whole height of that plate from the left posterior radial (Figs. 4 and 11). If, therefore, these homologies of Wachsmuth and Springer be accepted, it follows that the plate in question (*t* in their figures, *x* in ours) moved either from a position well above the radial circlet (*Iocrinus*) to one-half within it (*Ectenocrinus*), and finally entirely within it (*Hybocrinus*), or in the reverse direction. Either view is in direct contradiction to their statement on p. 132 that "there was no sinking of the plate *t*, which never moved from its place *above* the radials." That is another of those dogmatic general assertions which are useful to dispose of other people's theories, but are overlooked when the opinions of Messrs. Wachsmuth and Springer would be invalidated by them.

Rightly or wrongly (in the main, I believe, rightly) our authors have thus far explained the modifications of the anal area in Inadunata on principle 4 of the above list, namely, by the *shifting, atrophy*, and growth of certain constant elements. But when they turn to the plate which they term x, the case is altered. They start off by saying that this "is the homologue of the 'special' or 'first' anal plate of the Camerata, and rests upon the truncated posterior basal." This begs the whole position: it is equivalent to an assertion that x is suddenly developed in that position, and that it cannot possibly be homologized with any plate that does not truncate the posterior basal. As they express it on p. 132, "As the tube became larger, the radials spread out [i.e. apart], and the vacant space thus formed was filled by a new plate x." This explanation, though involving a different, almost an opposing, principle, may possibly be correct. But one would like to have some attempt at proof. One would expect to be shown primitive genera in which x first appeared as a narrow strip separating the radials and gradually widening. But no evidence of the kind is adduced. As for the argument based on a supposed homology with certain Camerata (p. 130), it must be recognized clearly that the appearance of x in Inadunata stands in no genetic relation to the appearance in Camerata. If the plate x be not a primitive structure, then its acquisition by Inadunata must have been independent of anything that may have taken place in Camerata. The sole value of the comparison lies in its suggestion that what was possible in one group was also possible in the other. But among Inadunate genera themselves, *Carabocrinus* has an obvious additional supplementary plate in the anal area of the cup; so that the possibility of a similar origin for x may be freely admitted. The probability, considering the persistence and frequency of the structure, is a different matter.[1]

Before accepting the above hypothesis as to the origin of x, we have to consider whether any other hypothesis has been proposed. Wachsmuth and Springer do in fact honour with courteous and detailed discussion the hypothesis proposed by me in April, 1890,[1] and already criticized by them in February, 1891.[2] Long ago[3] I showed that their representation of my views was based on misconceptions, and again,[4] while accepting a part of their criticism, took the opportunity of re-stating my main position. By ignoring these protests in this Monograph, Messrs. Wachsmuth and Springer have readily gained credit for the apparent demolition of my supposed theories. A short re-statement of views already published by me may therefore be pardoned.

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[1] Wachsmuth and Springer are wrong in thinking that I ever denied the general homology of x with any plate in the Camerata. In a passage, which they quote almost accurately, I once said, "it may be pointed out that, as interradials do not enter into the composition of the dorsal cup in any Fistulate, none of these [anal] plates can well be the homologues of interradials: in many of the Camerata actual interradials are present in the anal area, but in the Fistulata at least we must look elsewhere for the origin of the so-called 'anal' plates" (*Ann. Mag. Nat. Hist.* [6], v, p. 319). Having regard to the meaning at that time attached to the term 'interradials,' it is clear that this merely meant that the anals of Fistulata could not have been developed by the modification of interradials, since no such elements pre-existed in that suborder, whatever might have been the case in Camerata. As to the course of evolution in Ichthyocrinidæ and the Camerata I said plainly (op. cit., p. 331) "I can express no opinion." It should have been impossible to infer from this that "Bather makes no reference to the anal plates of the Ichthyocrinidæ, but regards the anals of the Camerata as morphologically distinct from those of the Fistulata . . . . because they [Fistulata] possess no interbrachials." Again, I said that one had no right to regard the anal plate of *Antedon* as a mere interradial when there were no such plates in the other interradii. Wachsmuth and Springer seem to think this nonsense (p. 139); yet in the very next paragraph they say that the "large interradial plate" on which rests the anal tube of *Thaumatocrinus* "is not a special anal, for a similar plate is interposed between the radials of the other four sides." But this is the precise and legitimate converse of the very argument that they ridicule.

First, then, I have maintained "that the lowest, median, posterior plate of the ventral tube is always this same plate (x), whether it be right above the radials, as in *Iocrinus* and *Merocrinus*, resting on the radials, as in *Heterocrinus* and *Castocrinus*, between the radials but not in line with them, as in *Homocrinus* and *Dendrocrinus*, in line with the radials, as in *Botryocrinus* and *Cyathocrinus*, or rising above the radials again, as in the later Decadocrinidæ [*Delocrinus*, *Ulocrinus*, *Erisocrinus*] and in the larval *Antedon*."[5] Any objections to this homology based on an alleged difference between anals and tube-plates, or on the supposed impossibility of plates sinking into the cup, have already been proved groundless by the admissions and arguments of the objectors themselves. Moreover, since, as regards the other anal plates (RA, *rt*), it is now admitted that change took place by gradual modification of constant elements, the burden of proof should lie with those who imagine the sudden introduction of a new element. The statement of Messrs. Wachsmuth and Springer that "this question was not discussed by Bather," however true it may be for my paper of 1890, is hardly one that should have been published five years after I had discussed the question in more than one place. As for the 1890 paper, it must be remembered that the distinction between tube-plates and anals was not attempted by Wachsmuth and Springer till 1891.[6]

Secondly, I showed that if the known genera were arranged in a series according to the admitted evolution of the radianal, then one could trace a gradual descent of the proximal median plate of the anal tube, from the left shoulder of the right posterior superradial, to a position between the posterior radials and resting on the posterior basal; and, following this, the descent of *rt* from a yet higher position into the space between *x* and r. post. Rs, and resting on RA; and, eventually, the retracing of these steps, accompanied by gradual atrophy of all the anal plates.

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[1] Ann. Mag. Nat. Hist. (6), vol. v, pp. 319–334.

[2] Proc. Acad. Nat. Sci. Philadelphia, vol. for 1890, pp. 345–392.

[3] Ann. Mag. Nat. Hist. (6), vol. vii, pp. 480–489, June, 1891.

[4] Ann. Mag. Nat. Hist. (6), vol. ix, pp. 64–66, Jan. 1892.

[5] Loc. cit. ult.

[6] In reply to their present assertion (p. 128) that they had always regarded the proximal posterior plate of *Iocrinus* and *Merocrinus* "as a plate of the tube," and had "never made any statement from which he might infer that we thought it represented the plate x; yet he quotes us in his diagrams as if we had done so in 1879," it is enough to say that in plate xvi of their "Revision of Palæocrinoidea," 1879, the letters *an* are applied equally to the median line of tube-plates in *Iocrinus*, to the plate which they now and always have homologized with the proximal of those median plates in *Anomalocrinus* and *Hybocrinus*, and to the plate x of *Cyathocrinus*. *With this before* me, why on earth should I have introduced into a diagram doubts *that had never occurred to* me or anyone else?

Now the present Monograph admits, as we have seen, the sinking and re-raising of *rt*; it also admits the sinking of the proximal median plate of the tube from its high position in *Merocrinus* and *Iocrinus* to its low position in *Heterocrinus* and *Ectenocrinus*, and its still lower position in *Hybocrinus*; finally, it admits the sinking of plate *x* from a level more than half its height above the radials, as in *Homocrinus*, to the level of the radials, as in *Cyathocrinus*, and its final expulsion from the cup. What it does not admit is the possibility of a proximal tube-plate sinking down between the radials so as to touch the basal.

Thus the missing link in our chain of evidence is so slight, and is of a nature so in accordance with links that are known or admitted, that we must demand some good reason for the refusal to imagine this link and for the substitution of an entirely novel postulate. The only tangible argument to be found in the Monograph is given on p. 133, as follows:—"If it were true that the plate of *Iocrinus* to the left of the suprarardial [r. post. Rs] passed down in later forms to the basals, it would mean nothing less than a partial revolution of the entire tube. This, however, is disproved by the structure as well as the palæontological development of the tube, which latter is generally composed of longitudinal rows of hexangular pieces, alternating in adjoining rows. In the earlier and simpler forms the tube consists of only five series, one to each interradius, that of the anal side resting upon plate *t*. Later on, as the tube grew larger, *a new row of plates was introduced with plate* x *supporting it.* When there are three series, as in *Dendrocrinus*, the third generally rests upon one side of the left posterior radial. The arrangement of the plates within the rows is so regular that if a sinking of the plate *t* had taken place it would certainly be indicated by some disturbance among the lower plates of the tube. In species where the tube has more than three rows, one or more of the primary rows dichotomize at some distance from the cup. [Compare Figs. 12 and 13.] The fact that the increase of the tube phylogenetically took place by the introduction of new rows of plates, is a strong argument in favour of our idea that the plate *x* is also a supplementary piece, and was introduced in the same manner as the plates which it supports."

If the statement which I have italicized were "a fact," it would be not merely "a strong argument," but absolute proof. But it is merely another phrasing of the very idea that is to be proved; and it is a phrasing that emphasizes the difficulty, for it maintains that the stout median line of the tube in *Iocrinus* and *Merocrinus* becomes replaced by another stout median line in *Homocrinus* and *Dendrocrinus*, and itself assumes a subsidiary position. No proof has yet been given that the added series may not be those starting from *rt* and *lt*, rather than the two adjacent ones starting from *x* and *lt*. As for "disturbance," Wachsmuth and Springer's own interpretation of *Dendrocrinus* and *Poteriocrinus* makes *rt* descend into the cup with no disturbance, but with the development of a new plate, which both in *Poteriocrinus* and *Cyathocrinus* occupies the position formerly occupied by *rt* and by the proximal median tube-plate of *Merocrinus* and *Iocrinus*. A similar process is shown by their drawings to have taken place on the left, though to a less extent. This "disturbance" is a mere bogey: if *x* did sink, it did not slide; it gradually grew downwards at its lower margin, as the basal and radianal grew upwards to meet it, and as it gradually became resorbed at its upper margin; and the adjacent plates were not disturbed, but all sank along with it, as has been shown. If "disturbance" is not all nonsense, then take a tube fixed at one end and "composed of five longitudinal rows of hexangular [*sic*] pieces, alternating in adjoining rows," and intercalate a sixth row. Try with bits of card. You cannot do it without "disturbance"; one at least of the adjoining rows must be raised or lowered. So that this "introduction of a new row of plates" effects the very change that it was designed to avoid.

These rather polemical arguments are introduced to show that Wachsmuth and Springer have neither disproved my hypothesis nor proved their own. What they have done is to show that the facts at present known do admit of more than one interpretation from the ordinarily accepted morphological standpoint. They might have adduced the additional argument that the gap between the supposed position of *x* above the radials and its position between the radials, almost coincided with the gap between Monocyclic and Dicyclic Inadunata. *Merocrinus* is the only Dicyclic genus of the former group; *Belemnocrinus* and *Missouricrinus*, the only Monocyclic genera of the latter. This of itself is enough to justify a cry for further facts.

The third conclusion of my 1890 paper is one that I have long since (1892) admitted to be non-proven. Nevertheless our authors deem it worth while to devote considerable space to a discussion of it, in the course of which they evince as much ignorance of their own writings as of mine, and a strange disregard of facts. The conclusion was "that *x* originated as a plate morphologically corresponding to an ordinary brachial," and it was suggested that the median row of tube-plates, or mid-rib, of the anal tube of *Merocrinus* and *Iocrinus*, represented a series of modified brachials (IIBr), up which the ventral perisome around the anus had extended.

The rejection of this hypothesis does not involve the denial of the previous conclusion as to the place of origin of the proximal tube-plate, though my critics persist in confusing the two. Their only serious argument is the impossibility of reconciling my hypothesis with the (alleged) homology between the mid-rib of the *Iocrinus* tube and the median anal series of Camerata, an argument sufficiently discounted by the impossibility of proving the homology in question.

On the other hand, various facts concerning the anal tube of Inadunata, some of which have come to my knowledge since I first propounded this hypothesis, warn us not to reject it too hastily. They are as follows:—The tube is closely connected with the right posterior ray, it being up this side that the rectum passes; in *Iocrinus*, *Merocrinus*, and *Castocrinus*, and, to a less extent, in *Heterocrinus*, *Ectenocrinus*, and *Ohiocrinus*, the proximal plate of the median row rests on the right posterior superradial;[1] in *Iocrinus* the articulation between the superradial and this proximal plate differs from that between the superradial and the first brachial only in size;[2] in many early Inadunata the

[1] Since I utilized this fact as an argument, Wachsmuth and Springer have persisted in denying its truth and have stigmatized my diagrams as incorrect. If it was not true, why did they in "Revision of Palæocrinoidea," iii, pp. 206, 207, write thus:—In *Ectenocrinus* the r. post. "radial . . . . upon its upper side supports the brachials, giving off laterally a small ventral tube"; and, in *Heterocrinus* "the smaller radial is transversely pentagonal, and resembles in outline a bifurcated plate [*axillare*]. It supports upon its sloping right side the brachials; toward the left the ventral sac as in *Iocrinus*."? My diagram of *Heterocrinus* was, as stated at the time, taken from the drawing of *H. bellevillensis* by W. R. Billings, whose description is in complete accordance with the foregoing remarks, as pointed out in "Crinoidea of Gotland, I" (1893), p. 72. I have no hesitation in saying that this mode of description is absolutely correct. I have most courteously been given the opportunity of studying a very large series of specimens of *Heterocrinus* and allied genera from the Trenton Limestone in the Walcott collection at the Museum of Comparative Zoology, Harvard. In these *x* is invariably closely attached to r. post. R*s*, although in many specimens it is clearly separated from l. post. R. In several the RR have become separated from one another, probably by pressure, and, when the posterior interradius is the one exposed, it is always seen that the line of division passes to the left and not to the right of *x*. This proves (so far as the consistent testimony of hundreds is to be held as proof) that the union between *x* and r. post. R is much stronger than that between *x* and l. post. R, even though the geometrical relations of the two radials to *x* may occasionally be similar. But *x* rarely does lie symmetrically to the adjacent radii: it is nearly always towards the right of the interradius: its two sides abutting on r. post. R*s* and its IBr_1 are straight and meet almost at a right angle, whereas the side or sides abutting on l. post. R and its IBr_1 generally form a continuous curve rather than an angle; in all cases where there is any swelling of the radials, or any development of axial folds, then *x* is clearly connected with the swelling or fold of r. post. R, and in no way with that of l. post. R (Fig. 17). These statements, which may be verified by anybody, refer specially to the Heterocrinidæ, though many of them hold good for species not in that family.

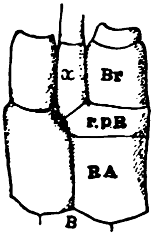

Fig. 17.—Anal area of type-specimen of *Heterocrinus isodactylus* in Dyer Coll. at Mus. Comp. Zool., Harvard. Said by S. A. Miller to be syn. of *Ohiocrinus compactus*. This shows far closer connection of *x* with r. post. R*s* than with l. post. R. (Enlarged.)

[2] Wachsmuth and Springer again criticize my application of the term 'axillary' to the r. post. R*s* of *Iocrinus*. They take no notice of my explanation ("Brit. Foss. Crin. III," Ann. Mag. Nat. Hist. [6], vi, Sept. 1890, p. 228). But there is more to be said for the application than I was then aware of. The accompanying drawings (Fig. 18) were made from specimens of *Iocrinus subcrassus* in the Mus. Comp. Zool. Harvard. I shows the interradial, superradial, and first brachial of the r. post. radius from inside; the anal tube is broken off, but its ventral groove is seen passing down the R*s* and coalescing in the R*i* with the ventral groove of the arm. II shows the articular surface of R*i* with *the dorsal ligament-fossa*, the two muscle-plates, and the *already dividing ventral groove*. III and IV show the two upper articular

plates of the median series are strangely like arm-plates, both in external view and in section, as I have figured in *Pisocrinus* and *Calceocrinus* ("Crinoidea of Gotland"); in *Iocrinus* the median series has an internal groove, similar to the ventral groove of the right posterior arm, with which it coalesces in the superradial; this evidence, as well as the external folds of the plates, shows that the median anal series of this and similar early forms was innervated from the axial cord of the right posterior ray.

These facts form an accumulation of evidence pointing in one direction. Is there any *a priori* reason why the suggestion should be rejected? It is not so very startling. I have not maintained that an arm-branch with its covering-plates and other organs was metamorphosed into an anal tube. I have not even suggested a change of essential function for the brachials themselves. The function of brachials is to afford a flexible support to extra-calycinal extensions of calycinal organs, and this is the function of the mid-rib of the anal tube in *Iocrinus*. Why, I have asked, may not the tegminal perisome become extended along an arm-branch in the region adjoining the anus, just as we know that it is extended in other regions? We know that arms may become partly incorporated in the cup by a web-like extension of tegminal plates

surfaces of R*s*, III on the left, bearing the median proximal anal, IV on the right, bearing the first brachial; in each are to be seen the dorsal ligament-fossa, two muscle-plates and fossæ, and a wide ventral groove merging into a narrow tongue where the axial cord lay. These facts prove: (1) that r. post. R*s* was united to the proximal anal in the same way as to IBr$_1$; (2) that the anal mid-rib was innervated by the same axial cord as was the r. post. arm. From which we infer (1) that the proximal anal in *Iocrinus* actually is "a plate corresponding to an ordinary brachial" in structure; (2) that the mid-rib may have arisen as a branch of r. post. arm; (3) that, in any case, the application of the term axillare to r. post. R*s* in *Iocrinus* is warranted by something more than the "angularity which occurs upon the upper face," "the form of the plates succeeding it to the left, and the slanting position of the posterior arm to the right" (W. & Sp., p. 129).

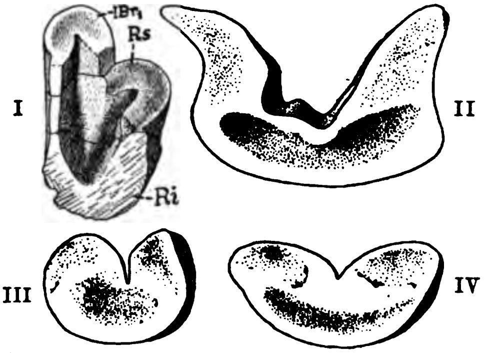

FIG. 18.—Ossicles of *Iocrinus*, probably *I. subcrassus*, in Mus. Comp. Zool. Harvard. I. Right posterior inferradial (R*i*) and superradial (R*s*) and first primibrach (IBr$_1$) seen from interior of cup. II. Upper articular surface of R*i*; groove on left goes to *x*, that on right to brachials. III. Left upper articular surface of R*s*, supporting *x*. IV. Right upper articular surface of R*s*, supporting IBr$_1$. *(Enlarged.)*

between them. In *Uintacrinus* some pinnules (which are only lesser arm-branches) are so modified by this incorporation that they have lost their original brachial character almost to their tips. *Calamocrinus* belongs to a family in which there is as a rule no anal tube of any consequence; but in this genus the tube is 20 mm. long and 5 mm. in diameter half-way up, and, according to Alexander Agassiz, it was "for more than half its length rigidly soldered to the edge of the adjacent arm and pinnule joints."[1] The food-grooves of the pinnules involved enter the tegmen at some distance from the bases of the pinnules, and thence pass to the mouth. Thus half the pinnule supports a food-groove with associated organs, while the other half supports an anal tube (Fig. 19). We have only to suppose the attachment of the tube to the first pinnule of the right posterior arm for a greater distance, and we should see a state of things almost precisely similar to that which, on my hypothesis, was the case in *Iocrinus.*

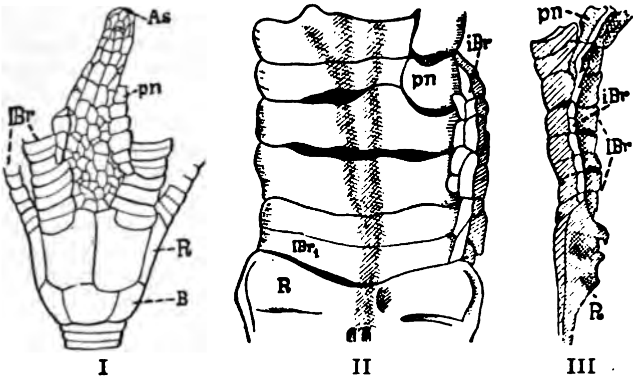

FIG. 19.—*Calamocrinus Diomedeæ.*

I. Posterior view of cup, showing attachment of anal tube to pinnules and proximal brachials. (× ⅘, from pl. iii, fig. 3.)

II. Radial and proximal brachials seen from inside of cup, showing attachment of interbrachials. (Much enlarged, and combined from pl. iii, fig. 6, and pl. xx, fig. 2.)

III. A similar portion seen from the side, showing the interbrachials (unshaded) attached to the brachials and pinnulars (shaded). (Enlarged, from pl. iii, fig. 5.)

All after Al. Agassiz. *As*, anus; B, basal; IBr, primibrachs; iBr, interbrachials; *pn*, pinnulars.

There is, then, no difficulty, morphological or physiological, in my hypothesis. But it will not be proved until there be found an ancestor of the Heterocrinidæ with the mid-rib of the anal tube free at its distal end and grooved. To such a condition that otherwise incomprehensible structure, the anal appendage of *Thaumatocrinus*, may be a partial reversion.[2]

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[1] "*Calamocrinus Diomedæ*": Mem. Mus. Comp. Zool. Harvard, vol. xvii, No. 2, Jan. 1892; see p. 36. The adjoining figures are adapted from this marvellously detailed work.

[2] P. H. Carpenter, "*On a new Crinoid* from the Southern Sea": Phil. Trans., 1883, *pt. iii, pp. 919–933, pl. lxxi; see pp. 925, 930.*

A more serious difficulty than any mentioned by Wachsmuth and Springer seems to me to lie in the existence of an anal between the posterior radials of *Hybocystis* and *Hybocrinus* (Fig. 6). These primitive genera undoubtedly suggest the view that both anal *x* and the radianal were original elements of the dorsal cup. I used once to think that some such view had been maintained by Wachsmuth and Springer,[1] but they have stoutly disowned the imputation.[2] On that view, both anal tube and arms would be outgrowths of the thecal wall, containing extensions of internal organs, and composed of a dorsal or outer series of supporting plates and a ventral or inner series of protecting plates. Thus the mid-rib of the anal tube would still be in a general way homologous (or more definitely, 'serially homoplastic') with the brachials; and *x* would be the serial homologue of the plate that we have been speaking of as the right posterior superradial, which would really be a modified brachial. The difficulties of this interpretation are obvious, but perhaps not insuperable.

On both my hypotheses, then, *x* corresponds more or less to a brachial, and is, as are the other anals of Inadunata, a constant element, the evolution and gradual disappearance of which may be traced. On the last hypothesis of Wachsmuth and Springer, *x* differs from all the other anals in being a supplementary plate, suddenly introduced, and almost as suddenly disappearing. In the absence of definite proof, each of my readers must decide which of the three views he will adopt as a working hypothesis. F. A. Bather.

(*To be continued.*)

II.—The Geology of the Country around Eastbourne. By Clement Reid, F.L.S., F.G.S. Geological Survey Memoir. 8vo; pp. iv, 15. (London, 1898. Price 6*d*.)

AMONG the most useful of the Geological Survey publications are the explanations to accompany the various sheets of the maps. In this respect the Irish Survey has set the best example, and has issued a complete series of Explanatory Memoirs. Much yet remains to be done in England and Wales and in Scotland to bring the work similarly up to date.

Now that the Survey in England and Wales is issuing its sheets on the new series of the Ordnance Survey Map the opportunity is taken of publishing short Memoirs, of which those by Mr. Reid on Bognor and Bournemouth have lately been noticed. We are now able to call attention to the issue of another on the Geology of Eastbourne, and this deals with the Cretaceous rocks from the Weald Clay to the Upper Chalk, with the Woolwich Beds and London Clay of Newhaven and Seaford, and with sundry superficial deposits. Illustrations of the characteristic fossils are given, and there are notes on disturbances and surface-erosion, on water-supply and economics.

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[1] "Brit. Foss. Crin. II": Ann. Mag. Nat. Hist. (6), vol. v (April, 1890); see pp. 322, 324.

[2] "*The Perisomic Plates*": Proc. Acad. Nat. Sci. Philadelphia, vol. for 1890, *Feb. 1891; see pp. 389, 390.*

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 23, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Sir A. Geikie drew attention to some specimens on the table which had been collected by the Geological Survey from the Silurian rocks of County Tipperary. These contained impressions that bore a close resemblance to flattened and drawn-out graptolites, and others that might be taken for mollusca or phyllopoda enlarged by cleavage. It seemed to him, however, extremely doubtful whether these forms were truly of organic origin. They were exhibited in the hope that the palæontologists in the Society might be able to throw some light upon them from the zoological side.

Dr. G. J. Hinde exhibited and commented on specimens of Devonian rocks sent by Prof. Edgeworth David and Mr. Pittman from the railway section at Tamworth, New South Wales, which had been received since their paper was read. The specimens included radiolarian shales and submarine tuffs containing impressions of *Lepidodendron australe*; similar shales with bands of tuff regularly interstratified; radiolarian chert irregularly broken up and intermingled with tuff; and hard shale with numerous radiolaria weathered out on the surface. Microscopic sections prepared from these rocks were also exhibited.

The following communications were read:—

1. "Note on a Conglomerate near Melmerby (Cumberland)." By J. E. Marr, Esq., M.A., F.R.S., F.G.S.

In this paper the author describes the occurrence of a conglomeratic deposit which shows indubitable effects of earth-movement, not only on the included pebbles, but also on the surface of one of the deposits. The rocks are coloured as basement Carboniferous rocks on the Geological Survey map. The Skiddaw Slates are succeeded by about 30 feet of a roughly stratified conglomerate, followed by 20 to 30 feet of rock with small pebbles, and that by a second coarse conglomerate. The pebbles possess the outward form of glacial boulders, but many of them are slickensided, fractured, faulted, and indented. The striæ are often curved, parallel, and covered by mineral deposit; the grains of the matrix are embedded in the grooves, while slickensiding often occurs beneath the surface of the pebbles and the striæ are seen to begin or end at a fault-plane. The surface of rock beneath the upper conglomerate was found to be slickensided. The way in which the surfaces of some of the pebbles have been squeezed off suggests the possibility that their angular shape may be partially or wholly due to earth-movement.

2. "Geology of the Great Central Railway (New Extension to London of the Manchester, Sheffield, and Lincolnshire Railway): Rugby to Catesby." *By Beeby Thompson*, Esq., F.G.S., F.C.S.

In this paper the portion of the line, 10 miles in length, from

Catesby to Rugby is described; as the ground falls while the strata rise in this direction, quite low beds in the Lower Lias are met with near Rugby. The lowest zone exposed is that of *Ammonites semicostatus*, in the lower part of which, and in Boulder-clay derived from it, *A. Turneri* has been found. The next succeeding zone, that of *A. obtusus*, although for the most part barren, yielded the characteristic fossils at its base. The *oxynotus*-zone is well developed and well displayed, besides being richly fossiliferous. The zone of *A. raricostatus* merges into that of *A. oxynotus* below and that of *A. armatus* above, and is not more than three or four feet thick. The *armatus*-zone, beds between that and the *Jamesoni*-zone, and the *Jamesoni*-zone itself follow; the middle beds of the latter being rich in *Rhynchonella* and *A. pettus*, the name of this ammonite is attached to the zone bearing them. The *Ibex*-zone occurs east of Flecknoe, covered by rocks yielding *A. Henleyi*; and the highest beds of this cutting appear to belong to the *capricornus*-zone. Lists of the characteristic fossils of each zone are given, followed by a complete list of all those found in the Lower and Middle Lias of the cuttings, with a statement of their distribution.

The glacial deposits are described under the following headings: Blue or local Boulder-clay, brown and grey contorted Boulder-clay, Chalky Lower Boulder-clay, (Mid-Glacial) sands and gravels, and red Upper Boulder-clay.

The paper is accompanied by a measured section along the railway.

3. "On the Remains of *Amia* from Oligocene Strata in the Isle of Wight." By E. T. Newton, Esq., F.R.S., F.G.S.

The specimens described in this communication were found by Mr. Clement Reid in the Bembridge Marls of Hamstead, and by Mr. Colenutt in the Bembridge Beds and in the Osborne Series of King's Quay, near Ryde. After a reference to species described in America and referred to the genera *Amia*, *Protamia*, *Hypamia*, and *Pappichthys*, the author proceeds to the description of the specimens in question, referring them all to the genus *Amia*. The specimens include the following bones: vertebræ, maxillæ with the supplementary bones, premaxillæ, bones of the skull, dentary bones, a parasphenoid, a clavicle, scales, and teeth. They are referred to two new species of the genus *Amia*. The paper concludes with a table of all the species hitherto recorded from America and Europe.

II.—December 7, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Geological Structure of the Southern Malverns and of the adjacent District to the West." By Prof. T. T. Groom, M.A., D.Sc., F.G.S.

The Raggedstone and Midsummer Hills, consisting essentially of massive gneissic and schistose rocks, are traversed by a curved depression which marks a line of profound dislocation, probably of the nature of a thrust-plane. This appears to dip towards the east, though with a relatively small hade. Along this depression occur strips of Cambrian and Silurian strata embedded in the Archæan massif, and indicating the presence of a deep and narrow dislocated synclinal fold. In places, the foliation of the schists shows a marked relation to the direction of this line, indicating in all probability a production of schists from the old material in post-Lower Palæozoic times.

The western boundary of the Archæan massif is everywhere a fault, apparently a thrust-plane, but with a small hade. The direction of this plane is in close relation with the axis of the overfold into which the Cambrian rocks are thrown to the west of these hills.

The western boundary of Chase End Hill is likewise a fault, which is probably a thrust-plane with a tolerably low dip towards the eastern side. The thrust here also appears to have been accompanied by a secondary production of schists from the old gneissic series; and the Cambrian strata are overthrown in the vicinity of the fault.

There is no evidence for the overlap of the Cambrian Series supposed by Holl, the circumstance that the various zones of the Cambrian Series strike up against the Archæan axis being due to faulting.

The Cambrian is represented by the following series:—

4. Grey Shales.	Upper Grey Shales.
	Coal Hill Igneous Band.
	Lower Grey Shales.
	Middle Igneous Band.
3. Black Shales.	Upper Black Shales.
	Upper White-leaved-Oak Igneous Band.
	Lower Black Shales.
	Lower White-leaved-Oak Igneous Band.
2. Hollybush Sandstone.	
1. Hollybush Quartzite and Conglomerate.	

Fossils are abundant in certain zones of each of the four subdivisions of the series.

The Grey Shales rest conformably on the Black Shales, but the mutual relations of the remaining subdivisions can be decided only by inference, the junctions being apparently everywhere faults. The junction between the Cambrian and Archæan is likewise a fault.

All four divisions of the Cambrian Series are invaded by small igneous bosses, laccolites, and intercalated sheets of diabase and andesitic basalt. These igneous rocks do not penetrate the May Hill Series.

The May Hill Beds seem to rest with apparent conformity upon the Grey Shales, and do not transgress across the various Cambrian zones on to the Archæan in the manner hitherto supposed, the presumed outliers being small patches faulted into the Cambrian.

The structure of the district is to be explained on the supposition that we are dealing with the western margin of an old mountain-chain overfolded towards the west; the eastern portion of this range lies faulted down and buried beneath the Permian and Mesozoic of the Vale of Gloucester. All the characteristics of a folded chain are present, namely, the profound folds, overfolds, thrust-planes, *and transverse faults*; and a typical Austönungs-zone *is seen to the west.*

2. "The Permian Conglomerates of the Lower Severn Basin." By W. Wickham King, Esq., F.G.S.

The rocks thus described are the calcareous conglomerates included in the Middle Permian of the Shropshire type, and exposed north of the Abberley and Lickey Hills. Three calcareous horizons occur, interstratified in sandstones or marls and surmounted by the Permian breccia. It was the opinion of Ramsay and others that the materials of the calcareous horizons and of the Permian breccia had been brought from the Welsh border; but Buckland and Jukes, among others, claimed a southern derivation for those of the Permian breccia, from local hill-ranges to the south. The latter view accords with the fact that the pebbles composing these calcareous horizons, and also the broken fragments constituting the Permian breccias north of the Abberley and Lickey Hills, are coarser in the south-easterly direction, and gradually become finer to the north-west.

The fragments embedded in the Middle Permian calcareous bands near the Lickey are chiefly of Archæan rocks, but in all the other districts described there are very few rock-fragments older than Woolhope Limestone. On the other hand, pebbles of dolomitic Wenlock and Carboniferous Limestones are abundant, while Aymestry Limestone, Old Red, Carboniferous, and Lower Permian Sandstones occur in greater or less abundance; and all these rocks, except the Carboniferous Limestone, may be seen *in situ* near at hand to the south. A summary of work done in the Halesowen Coal-measure conglomerates and in the Permian breccia north of the Abberley and Lickey Hills is given, to bring out one of the lines of argument adopted.

(1) Ridges near the Lickey were denuded down to the Archæan rocks in Upper Carboniferous time; therefore, as might have been expected, both the adjacent Upper Carboniferous conglomerate and the Middle Permian calcareous cornstones are composed of such fragments of Archæan rocks as are to be found *in situ* there, or at Nuneaton; and the Upper Carboniferous conglomerate is also largely composed of Palæozoic rocks identical with those *in situ* on the flanks of the Lickey.

(2) The Middle Permian calcareous conglomerates of the other districts described are for the most part made up of fragments not older than the Woolhope Limestone, which were presumably derived by denudation from ridges which had become more extensive.

(3) The Lickey ridges having been denuded to the Archæan rocks and the more extended area to the Woolhope Limestone, the later Permian breccias are composed of Archæan fragments near the Lickey, but of rocks not newer than the Woolhope Limestone in the other districts north of the Abberley and Lickey Hills.

The author has for several years called the ancient ridges from which these materials were derived the 'Mercian Highlands,' and claims that the Palæozoic and Archæan rocks composing the stumps of these highlands lie almost entirely buried under the Trias of the Midlands south and east of the S.E. Shropshire and S. Staffordshire regions.

Very sincerely yours.
Alfred R. C. Selwyn

DR. A. R. C. SELWYN, C.M.G., F.R.S., F.G.S.
Director Geol. Surv. Canada, 1869-1894.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. VI.

No. II.—FEBRUARY, 1899.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists: Alfred Richard Cecil Selwyn, C.M.G., LL.D., F.R.S., F.G.S., etc.

(WITH A PORTRAIT, PLATE II.)

THE number of eminent living geologists surviving since the days of De la Beche and Ramsay and the beginnings of the Geological Survey must indeed be very few, but in Dr. A. R. C. Selwyn, the subject of this brief notice, we have a living illustration of one of those active and energetic early workers whose labours have extended from Britain to Australia and Canada, and who, after half a century of active service in the field, is now enjoying his well-merited repose in British Columbia, "the land of the far West."

Alfred R. C. Selwyn, the son of the Rev. Townshend Selwyn, Canon of Gloucester, was born in 1824, and educated in Switzerland, where he early imbibed a passion for geology. In the year 1845, at the age of 21, he was first employed on the Geological Survey of Great Britain, and received his earliest lessons in the art of geological surveying from A. C. Ramsay; but he soon proved himself so proficient in the work of field-surveying that he was speedily entrusted with the task of mapping a large tract of intricate Lower Silurian rocks in North Wales, which he carried out in a masterly manner.

At that time Sir Henry De la Beche had charge of the whole organization of the Geological Survey, with the title of Director-General. The immediate supervision of the work in England and Wales (and afterwards in Scotland) was assigned to A. C. Ramsay, as local Director for Great Britain. Edward Forbes was appointed Palæontologist; Sir W. W. Smyth became Mining Geologist; Sir Joseph Hooker, Botanist; Dr. Lyon Playfair, Chemist; Richard Phillips was in charge of the Laboratory and Museum; and Robert Hunt, Keeper of Mining Records. The staff of Geological Surveyors under Ramsay comprised W. T. Aveline, Trevor E. James, D. H. Williams, H. W. Bristow, W. H. Baily, and A. R. C. Selwyn. R. Gibbs was the Collector of Fossils, and proved to be one of the best men in that capacity ever attached to the staff of the Survey. Mr. C. R. Bone was employed as Artist to draw fossils described by the Palæontologist; and Mr. J. W. Lowry was Engraver both of the plates of fossils and of most of the early geological sections. Never *since has the Survey* been so admirably equipped.

Of this excellent body of geological workers only Sir Joseph Hooker, W. T. Aveline, and A. R. C. Selwyn remain to us; the others have all gone over to the majority. This is also true of Oldham, J. Phillips, Murchison, J. W. Salter, J. Beete Jukes, and some others who joined the Survey before Selwyn's retirement. Of the older members who joined afterwards, E. Hull, H. H. Howell, G. H. Kinahan, and Robert Etheridge still survive.

In November, 1845, we find Selwyn located at Machynlleth, and accompanying Ramsay in making some traverses into the rugged country of Cader Idris, from which in subsequent years they were to work out the complicated volcanic geology of North Wales.

In May and June, 1846, Selwyn was at work from Dolgelly, and Aveline was tracing the boundaries of the Silurian series from Llanbrynmair eastwards to Church Stretton and the Longmynd. Ramsay spent much time with Selwyn, and records "glorious days and glorious scenery"; "out with Selwyn along the front of the Cader cliffs," and "over the top of Cader Idris; a long day's work and a splendid scramble." He also adds, "Selwyn's work good."

In August, 1847, we find Selwyn located at Ffestiniog, where he was joined by Ramsay, Playfair, Jukes, and Gibbs; Ramsay (having accidentally sprained his ankle) was mounted on a pony and went over the ground with his colleagues, and discussed with them some of the problems met with in the course of their mapping.

In the Autumn of that year Selwyn was at Capel Curig, and Jukes at Yspytty Evan. Before the end of the year Jukes was transferred to the South Staffordshire Coalfield. Writing to Ramsay (Oct. 15, 1847) Jukes says: "It so happens that the last time I saw Selwyn, we were mutually wishing that you would send us both into Staffordshire together."[1] This proposal was not, however, adopted. After leaving North Wales, Selwyn carried on the Geological Survey work in parts of Shropshire, as far north as the Liassic outlier of Prees. To show that a kindred spirit moved the two young geologists, we find them in 1848 communicating a joint paper to the London Geological Society on their North Wales investigations.[2]

Whilst quartered at Port Madoc and Dolgelly in June, 1848, Selwyn was once more visited by Ramsay, and together they went forth again to the hills south-west of Craig-y-Cae, "mapping in some faults and a lot of strange dykes and spots of squirted traps." Ramsay writes: "Selwyn and I separated and took different ground, and often met again to compare and compile. A lovely day, and the (cloud) effects over the valley of Dolgellaw and the towering range of Cader Idris most strange and glorious."

In October, when Selwyn was at Beddgelert, mapping the Snowdon area, we find him visited by Ramsay, who was quartered at Llanberis. Ramsay writes: "Started for the hills at the top of the Pass, and sent Gibbs to search the ridge of Snowdon; Sir Henry De la Beche and Forbes followed an hour later for the top. While at work on the side of Crib-goch I heard Selwyn's well-known shrill shout, and soon discovered him on the top of a crag on Crib-goch. So we joined and compared notes, and soon put matters straight at Glaslyn. We then passed on to the top, often standing to discuss, and just as we got to the bottom of the peak descried our party coming down."

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[1] See Letters, etc., of J. B. Jukes, 1871, pp. 302, 314, 322, and 341.

[2] A. R. C. Selwyn & J. B. Jukes, "Sketch of the Structure of the Country *extending from* Cader Idris to Moel Siabod, North Wales": Quart. Journ. Geol. Soc., *vol. iv (1848), pp. 300–302.*

Perhaps the most enjoyable episodes of this geological life in Wales, the memory of which would be long cherished, were the occasional interchange of visits of members of the staff with each other, and those paid them by their energetic chief, Sir Henry De la Beche, from London. Whilst Ramsay and Forbes were staying at Llanberis, Selwyn, who was located at Beddgelert,[1] would sometimes walk across the hills and spend the evening and night with Ramsay, who in turn occasionally crossed the watershed and landed in time for dinner at Beddgelert. Many pleasant stories were recorded in the principality of the sayings and doings of these jolly hammerers long years after they themselves had left the scene of their labours for other, and in Selwyn's case distant, shores.

In September, 1849, Mr. Selwyn, having completed the survey of the ground lying between the Snowdon range on the north and Ffestiniog and Tremadoc on the south, turned his attention to working out the Lleyn peninsula from Pwllheli. In December of the same year he again joined Ramsay and Jukes at Aber, where they appear to have had a very pleasant meeting,—"joking and making fun, all of us, all night," says Ramsay. (Life of Ramsay, p. 158.)

On the 30th April, 1850, Selwyn, Jukes, and Ramsay once more met at Merchlyn in North Wales. There were still various unfinished parts to complete, likewise sundry lines regarding which they had to confer with their colleagues.

Ramsay records that he was "out on the hills with Selwyn [on the 4th May, 1850] as far as the cliffs under Carnedd Llewelyn and down by Melynllyn and Llyndulyn. Got some good work done." He adds: "Selwyn executed a most perilous feat of cliff-climbing; a slip and he would have been slain" (op. cit., p. 161). Writing to Salter on the 31st May, 1850, from Caernarvon, Ramsay says: "Selwyn and I are here putting a final touch to all the difficulties and erst-seeming contradictions on this side the Straits"; and on the 12th October he was "helping Selwyn to put some finishing touches to the mapping of the Cader Idris region." How many *final touches* we wonder have been added towards the elucidation of these Welsh geological difficulties in the subsequent half-century! Again, quoting from the life of Sir Andrew Ramsay: "There still remained a portion of Anglesey to be surveyed before the maps of North Wales could be regarded as complete and ready for the engraver. De la Beche had himself traced the lines across some parts of that county, and other portions had been mapped by

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[1] *September, October,* 1848.

W. W. Smyth. Ramsay and Selwyn (early in November, 1850) crossed into Anglesey with the object of filling in the unfinished portions and completing the whole" (p. 171). "During the day he and Selwyn traversed the rocky northern coast of the island, charmed with 'the cliffy foregrounds, the white breakers, the great misty plains of Anglesey, and the snow-covered mountains rising beyond so still and grandly.' At night they had the shelter of little inns, sometimes of the homeliest kind" (p. 173), and once they received an invitation to make the Rectory of Llanfairynghornwy their headquarters for a day or two. It was during this investigation that, in a letter to Ramsay, November 11th, 1850, De la Beche intimated to him that he had recognized conglomerates at the base of the Cambrian series of Anglesey, and that most probably the rocks underlying these were of *pre*-Cambrian age. Selwyn clearly detected the unconformability of the lowest Cambrian strata upon an older series of schists, but Ramsay on this occasion differed from De la Beche and Selwyn, and on the maps published by him no pre-Cambrian rocks were there shown.

One is struck by the conviction that the labours of the conscientious geologist are never-ending, for we find that in October, 1851, "There were still points of detail and some questions of interpretation of geological structure to be settled in the area in North Wales mapped by Ramsay and Selwyn. Selwyn accordingly had gone back to Dolgelli to look into these, and there Ramsay joined him." Ramsay writes in his diary, October 17th, 1851: "Held a council with Selwyn on the Shropshire sheets, etc. His work there and here [North Wales] is the perfection of beauty" (op. cit., p. 193). "One of the most striking in the whole series of sections published by the Geological Survey" (writes Sir A. Geikie) "runs from the top of Snowdon parallel with the Llanberis valley to the Menai Straits at Llanfair, whence it was afterwards continued across Anglesey. On the other side it was prolonged south-eastwards into the country mapped by Selwyn, and was carried by him into Merionethshire, across Cynicht, Moel Wyn, and Aran Mowddwy, and was continued by Aveline across Montgomeryshire." Sir A. Geikie adds: "The geological structure is portrayed by Ramsay and Selwyn with a boldness and vigour, and at the same time with an artistic feeling, which had hardly been equalled in geological section-drawing" (op. cit., p. 165).

Ramsay records that in 1851 Selwyn was present, 18th January, at the annual dinner of the Survey, known as "the Royal Hammerers." "And oh, wasn't it a jolly dinner!" No doubt he had also been present at many earlier gatherings.

The Welsh work of completion and revision took longer than had been anticipated. At the close of 1852 it was not finished; and Selwyn relinquished the happy Survey days at the end of July in that year. For, following the blessed example set by his former colleagues, Thomas Oldham, Edward Forbes, and A. C. Ramsay, *Mr. Selwyn* also became a Benedict, and took to himself a wife, *Matilda Charlotte,* daughter of the Rev. Edward Selwyn, rector of

Hemingford Abbotts, Hunts; and in the year following he was appointed by the Colonial Office Director of the Geological Survey of the newly-formed Colony of Victoria,[1] Australia, which had just then entered upon all the excitement and interest of the opening up of its wonderful goldfields. Here Selwyn's past experiences in unravelling the intricate Lower Silurian rocks of North Wales, with their associated volcanic deposits, served him in good stead in mapping the Silurian strata of Victoria, with its gold-bearing rocks and auriferous gravels of different ages, and in tracing the relations of the latter to the Miocene beds of the Colony, so rich in their varied Eocene molluscan fauna.

Mr. Selwyn was ably assisted by C. S. Wilkinson, H. Y. L. Brown, C. B. Brown, R. Etheridge, jun., and other geologists; and in addition to an admirable series of geologically coloured maps of the Colony and reports, he made the following important communications:—

1. "On the Geology and Mineralogy of Mount Alexander and the adjacent country lying between the Rivers Loddon and Campaspe": Quart. Journ. Geol. Soc., vol. x (1854), pp. 299-303.
2. "Report on the Geological Relations of some of the Coal-seams of Van Diemen's Land, their probable extent, and relative economic value": Van Diemen's Land, Roy. Soc. Papers, iii, 1855–9, pp. 116–141.
3. "On the Geology of the Goldfields of Victoria": Quart. Journ. Geol. Soc., vol. xiv (1858), pp. 533–538; and Geologist, vol. i (1858), pp. 163, 164.
4. "Notes on the Geology of Victoria": Quart. Journ. Geol. Soc., vol. xvi (1860), pp. 145–150.
5. "Geological Notes of a Journey in South Australia from Cape Jervis to Mount Serle": Geogr. Soc. Proc., vol. v (1861), pp. 242-244.
6. "Report on the Auriferous Drifts and Quartz-reefs of Victoria.—Observations on the probable Age of the 'Lower Gold Drifts'".: Victoria, Australia, May 4, 1866. Reprinted in the Geol. Mag., Vol. III (1866), pp. 457-459.

The communication made to the Geological Society by Mr. Selwyn on March 10, 1858, and the Report on Auriferous Drifts, etc., Victoria, 1866 (Geol. Mag., Vol. III, p. 457), are among the most important of Mr. Selwyn's written contributions to the geology of Victoria.

He was almost continually engaged in the field with his assistants, or in travelling over the Colony, and was indefatigable in the discharge of his duties as Director of the Survey from 1853 to 1869, when he retired, the Survey having been brought to an abrupt close by the Colonial Legislature refusing to vote the necessary supplies to carry on the work.

In 1865 Mr. Selwyn sent over to the care of the late Mr. H. M. Jenkins, at that time Assistant Secretary of the Geological Society, an excellent collection of Murray River Tertiary shells, which have since been deposited in the Museum of the Geological Society, Burlington House.[2]

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[1] The *whole area* of the Principality of Wales is 7,378 square miles: Victoria is the smallest of the Australian colonies and its area is 87,884 square miles! What a contrast for Selwyn after seven years among the mountains of Wales!

[2] For a most interesting account of the Tertiary deposits of Victoria, based upon Mr. Selwyn's reports and papers, see British Association, Section C (Geology), Norwich, 1868; and *Geol. Mag., Vol. V (1868)*, p. 566, by H. M. Jenkins, F.G.S.

Mr. Selwyn's geological services were, however, far too valuable to be permitted to lie fallow for any length of time, and on the retirement of his old friend Sir William Logan, that same year (1869), from the office of Director of the Canadian Geological and Natural History Survey, Montreal, Logan recommended the Canadian Government to appoint Selwyn as his successor, a piece of advice which they at once accepted and acted upon.

Although, from the commencement of his geological career, Selwyn's life had been one of almost incessant and active labour in the field and in the office, he could scarcely have found a more energetic man to follow after than Sir William Logan, or a wider field to travel over than the Dominion of Canada. This territory is nearly as large as Europe, stretches from the Atlantic to the Pacific Ocean, and is estimated to contain a total area of 3,315,647 square miles, *exclusive* of the great lakes and rivers.

His staff, though small, included such well-known geologists as Mr. James Richardson, Dr. Robert Bell, Dr. T. Sterry Hunt, the present Director (Dr. G. M. Dawson, C.M.G.), J. B. Tyrrell, J. F. Whiteaves, B. J. Harrington, H. M. Ami, A. H. Foord, and some others, Mr. E. Billings being the chief palæontologist.

During the 25 years, from 1869 to 1894, that Mr. Selwyn filled the office of Director of the Geological Survey of Canada, twenty large volumes of Annual Reports, with accompanying maps and sections, were issued from the Survey Offices in Montreal or later on from Ottawa. In addition to these, five other volumes were published by Billings, Macoun, and Dawson on Invertebrata and Plants; four fascicules by A. H. Foord, E. O. Ulrich, T. Rupert Jones, and Dr. Rüst on Micropalæontology; and four by J. F. Whiteaves on Palæozoic and Mesozoic fossils.

Notwithstanding the arduous administrative duties which Selwyn was called to fulfil in planning out the work to be carried on by his staff, and arranging all matters relating to the expenditure of his grant, as well as in editing the reports of his assistants and writing his own, he yet found time to traverse and personally explore large extents of unmapped territory. This was at a time when maps were few and bad, when no railways and but few roads existed, and long journeys had to be performed by boat or in the saddle, and often on foot, in order to reach points of vantage for geological and trigonometrical surveying. Add to all this the necessity of having to camp out and carry supplies sufficient for three months, and one begins to realize that a geologist's life in a large and mainly unexplored country, such as the backwoods of Canada, is not always an altogether happy one.

In addition to these arduous duties, the Dominion Government called upon Mr. Selwyn to act as Assistant to the Canadian Commissioners at the Centennial Exhibition held in Philadelphia in 1876, at the Paris Universal Exhibition in 1878, and at the Colonial and Indian Exhibition in London in 1886; involving an *enormous* amount of labour, and including the preparation of *descriptive* catalogues of the economic minerals and notes on the stratigraphical rocks exhibited in the Canadian Court on each occasion.

Of his miscellaneous writings there are not many to record at this time, but the following may be noted:—

7. "On the Discovery of Reptilian Footprints in Nova Scotia": GEOL. MAG., Vol. IX (1872), pp. 250, 251.
8. "Notes on a Journey through the North-West Territory, from Manitoba to Rocky Mountain House" (1874): Canadian Naturalist, vol. vii (1875).
9. "The Stratigraphy of the Quebec Group and the older Crystalline Rocks of Canada" (1879): Canadian Naturalist, vol. ix (1881), pp. 17–31.

In 1871 Mr. Selwyn was elected a Fellow of the Geological Society of London, and in 1874 a Fellow of the Royal Society.

In 1876 he was awarded the "Murchison Medal" by the Council of the Geological Society of London—"in recognition of his services to Silurian geology. . . . . As one of the officers of the Geological Survey of this country, engaged in unravelling the intricate Lower Silurian rocks of North Wales with their associated volcanic deposits; as afterwards in charge of the Geological Survey of Victoria, mapping its Silurian strata, its gold-bearing rocks and auriferous gravels of different ages, and tracing the relations of the latter to the Miocene beds of the colony and to the older rocks; as subsequently the successor of Sir William Logan in the direction of the Geological Survey in our North American territories from the Atlantic to the Pacific Ocean, the labours of Mr. Selwyn have extended over an enormous field. How successfully he has worked in it, the numerous and excellent maps and sections executed under his superintendence, and his various reports and papers fully testify.

"There is something peculiarly appropriate in the Medal founded by Sir Roderick Murchison being given to one whose labours, like his own, have lain so much among Silurian and Palæozoic rocks, among goldfields, and in the direction of geological surveys. While it marks [said the President] our appreciation of Mr. Selwyn's services to Geology, it will, I trust, not be less welcome to him as a proof that, though absent, he is not forgotten at home."[1]

In the course of his fifty years' work as a geologist, Mr. Selwyn has been spontaneously elected to more than fourteen scientific societies in various parts of the world, including the K.-k. Geologischen Reichsanstalt Wien. He was created C.M.G. in 1886.

It would be impossible in such a notice as this to do full justice to so eminent and illustrious a geologist, but we trust that what has here been so imperfectly written may serve to "keep his memory green" in the recollection of some of those friends who, like the writer, can recall Mr. Selwyn, not only by means of his written memoirs, but by a personal knowledge of the man and his worth.[2]

H. W.

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[1] See President's speech, Feb. 18, 1876: Quart. Journ. Geol. Soc. Lond. (Proceedings), vol. xxxii, p. 49.

[2] The writer is much indebted to Sir A. Geikie's "Life of Ramsay"; to his friend J. F. Whiteaves, F.G.S., for various references; and to G. Pringle Hughes, Esq., J.P., Middleton Hall, Wooler, Northumberland, for the photograph here reproduced, and for valuable *information, a part of which is* embodied in this notice.

II.—PROFESSOR HULL "ON THE SUBMERGED PLATFORM OF WESTERN EUROPE."

By the Rev. OSMOND FISHER, M.A., F.G.S.

TO appreciate more fully Professor Hull's interesting paper "On the Submerged Terraces and River Valleys bordering the British Isles," it is necessary to refer to the Transactions of the Victoria Institute,[1] in which the paper is illustrated by a map showing the contour-lines and soundings. The author thinks that the steep descent from the surface of the 100-fathom plateau to the abyssal floor of the Atlantic is analogous to an escarpment, instancing the Cotteswold Hills and other examples, and argues from this that the steep descent in question has been due to the forces of subaerial denudation, and has had a terrestrial origin. But in his "general conclusion" he mentions marine as well as atmospheric erosion. This seems to show that he does not exclude the supposition of the descent being possibly an ancient sea cliff, to which one would think it more analogous than to an escarpment, for, as Mr. Jukes-Browne observes, the latter term implies the termination of a series of beds of one geological age, which it cannot be supposed occurs here.

I notice that in this discussion there has been no reference made to a masterly paper by the late Mr. R. A. C. Godwin-Austen—"On the Valleys of the English Channel."[2] He tells us that he "had frequent opportunities of cruising about this Channel, and had been enabled at one time or another to visit nearly every portion of its shores on either side, and to examine its bed with the dredge and sounding-lead." The map which illustrates his paper consequently gives several interesting points of detail, which do not appear in the Admiralty chart of the English Channel. He says that "along the opening of the Channel there is an obvious configuration of hill and valley, and an amount of inequality equal to that of the most mountainous parts of Wales." Regarding the junction of the channel with the Atlantic we read—"Beyond the 200-fathom line the outline is irregular, and sinks rapidly to very great depths. This remarkable fact occurs not only at one particular spot, but is continued northwards, and in the contrary direction has been traced by Captain Vanhello from Cape Finisterre to the parallel of the Lizard." He states that the ridge of the Little Sole Bank is placed on the east edge of the 200-fathom line. "Of the true nature of such a sudden line of depression we can at present only form conjectures. It may represent lines of old escarpments, or, should lines of sea cliffs have gone down rapidly into deep water where no mechanical action could modify them, such features would be preserved. Lines of faults and upheaval would also prevent such unequal soundings; but the outline is too irregular to represent the termination of the sedimentary mass of the present seas; besides which we have constant indications of a surface of bare rock."

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[1] Vol. xxx (1898).

[2] *Quart. Journ. Geol. Soc.*, vol. vi (1849), p. 69.

It is clear that Godwin-Austen's conclusions are quite compatible with the existence of the river-valleys, which Professor Hull thinks that he has traced, and he appears to consider that the landscape of the Channel, if it were laid bare, would be very diversified. He also appears to regard this landscape as the outcome of long-continued agencies, both marine and terrestrial, while, if I understand him rightly, he attributes the original formation of the Channel valley to plication dating from Eocene times. As regards the remark that of the true nature of the sudden line of depression from the continental plateau to the ocean floor we can only form conjectures, will it not help us in our conjectures to notice the very remarkable parallelism between the outlines of the western coast of the Old World and the eastern of the New? Surely there must be a cause for this peculiar feature in some way connected with the formation of the basin of the Atlantic. It seems as if a single original continent had been split into two masses, which had subsequently separated. This idea appears to have occurred to M. A. Snider, but I have been unable to get a sight of his work.[1] Two of his diagrams are copied into "Pepper's Playbook of Metals."

If there is any foundation for such a supposition, the edges of the continental plateaux on the opposite sides of the Atlantic ought to be the two sides of the rent, and ought to fit one another still more accurately than the coastal profiles do, because in the lapse of ages these would have become much modified. Would it not be worth while for those who have been studying the two plateaux to notice whether this is the case?

I have offered a speculation on the *cause* of this great rent in *Nature*[2] and subsequently in my "Physics of the Earth's Crust,"[3] and it is not needful to recapitulate it here.

III.—Preliminary Note on *Prolimulus Woodwardi*, Fritsch, from the Permian Gaskohle at Nyřan, Bohemia.

By Dr. Ant. Fritsch,
Director of the Royal Bohemian Museum in Prague.

SOME years ago I received a fossil preserved in pyrites from the Gaskohle at Nyřan. No details could be seen under the microscope, and I was not sure if it were a *Limulus* or a seed. At an exhibition by Architects held last year at Prague I saw a specimen of a similar fossil with two of its appendages preserved, and I was fortunate enough to acquire the same for our Museum. I then re-examined all my material previously collected, and found appendages in other specimens also. Several plates with drawings of these objects will appear in the second part of the fourth volume of my work, "Fauna der Gaskohle," but as this work will require more than a year before it can be published, I hasten to give a preliminary sketch of this Permian Xiphosure, which I dedicate to my friend Dr. Henry Woodward, one of the chief authorities on fossil Crustacea in England.

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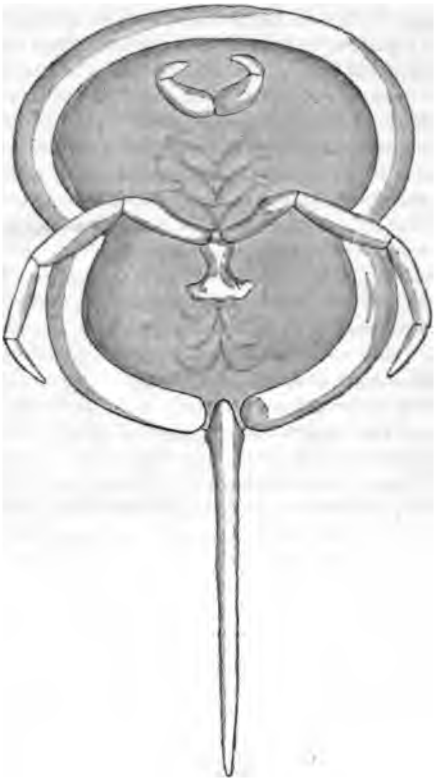
[1] "La Création et ses Mystères dévoilés."

[2] Vol. xxv (1882), p. 243.

[3] Second edition (1889), chap. xxv.

The body consists of two rounded shields, with thickened margins measuring 13 mm., the telson is 14 mm. in length, the whole length of the specimen being 27 mm.



Diagrammatic sketch of *Prolimulus Woodwardi*, Fritsch, enlarged four times.

The dorsal surface is generally covered with some calcareous coiled discoidal tubes of *Spiroglyphus vorax*, Fr. On the ventral part of the cephalothorax (if made wet with gum-arabic) five pairs of extremities can be detected, the first being very strongly curved inwards, the fifth long and slender, being supported by a sternal element.

On the ventral surface of the abdomen we can see rounded plates, probably the modified abdominal appendages covering the respiratory organs, or branchiæ. The telson is inserted in an invagination of the hinder margin of the abdomen.

I hope that the galvanoplastic casts which I have had prepared of some of the developed natural impressions will help us to recognize more of the details of the structure of this Permo-Carboniferous *king-crab*. *Prolimulus* very closely resembles one of the embryonic *stages of the living* North American *Limulus polyphæmus*.

The earliest known Limuloid Crustacean, named *Neolimulus falcatus*, figured and described by Dr. H. Woodward in 1868 (see Geol. Mag., Vol. V, p. 1, Pl. I, Figs. 1, 1*a*), is from the Upper Silurian of Lesmahagow, Lanarkshire, Scotland. Mr. W. H. Baily described *Bellinurus Kiltorkensis*, Baily (1869), from the Upper Old Red Sandstone, Kiltorcan, Ireland. The genus *Bellinurus* was established by Mr. C. König, in 1820, for certain small king-crabs from the Coal-measures of Coalbrookdale, Shropshire, under the specific name of *B. bellulus*. To this have been added *B. arcuatus* and *B. reginæ*, Baily (1863), Coal-measures, Queen's County, Ireland; *B. Kœnigianus*, H. Woodw. (1872), Coal-measures, Dudley; *B. Danæ*, Meek & Worthen, Coal-measures, Illinois, U. S. America; *Prestwichia*[1] (*Limulus*) *anthrax*, Prestwich, sp. (1840), and *P. rotundata*, Prestwich, sp., Coal-measures, Coalbrookdale, Shropshire; and *P. Birtwelli*, H. Woodw. (1872), Coal-measures, Padiham, Lancashire.

King-crabs have been described from the Muschelkalk,[2] the Jurassic, the Cretaceous rocks, the Tertiaries, and are now living in the seas of Eastern North America and of Japan. Our present Permo-Carboniferous example connects the Upper Coal-measures with the Secondary rocks, and completes the chain of life of this remarkably persistent type of the Xiphosura from the Upper Silurian to the present day.

IV.—On a Section in the Westleton Beds at Ayot Brickfield.

By Horace W. Monckton, F.L.S., F.G.S.

On May 14th, 1898, a party of the Geologists' Association visited Ayot under the direction of Messrs. John Hopkinson, F.G.S., and A. E. Salter, B.Sc., F.G.S. An account of the excursion will be found in the Proceedings of the Association, vol. xv, p. 308, and I think the following additional note of one of the sections visited will be of interest.

The section was at the eastern side of the brickfield close to Ayot station, and the general relation of the beds seen is shown in the accompanying Figure.

Prestwich, in his paper on the "Relation of the Westleton Beds," etc., published in 1890,[3] remarks: "Notwithstanding the extreme denudation which the high chalk plain extending from Hertfordshire into Bedfordshire, Buckinghamshire, and Oxfordshire has undergone, a few small outliers of Lower Tertiary strata still remain, rising above the general level of the chalk plateau with its scanty Glacial Drifts and its 'Red Clay with flints.' These little isolated hills are frequently capped by a gravel- or shingle-bed, which I believe to be of Westleton age." He then gives several localities, and amongst them Ayot, 406 feet O.D.

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[1] Originally described by Prestwich in his "Geology of Coalbrookdale" as '*Limulus*' *anthrax*. The genus *Prestwichia* was established by Woodward in 1867: see Quart. Journ. Geol. Soc., vol. xxiii, p. 32.

[2] *Limulus priscus*, Münster, Muschelkalk-Dolomit, Laineck, near Bayreuth: K. A. Zittel's "Handbuch der Palæontologie," ii, p. 645 (1881).

[3] Quart. Journ. *Geol. Soc., vol. xlvi, p. 138.*

Thus I take it that Prestwich would have classed the gravel-bed 2 in the above section as Westleton Beds, and its composition and appearance favour the view that it does belong to the gravels which Prestwich assigns to that series in this part of England.

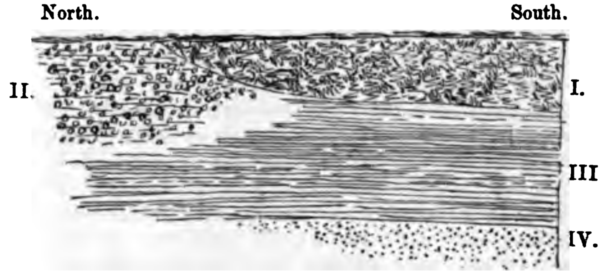

Diagram-Section in the Ayot Brickfield.
Level of surface nearly 400 feet O.D.

I. Boulder-clay, about 12 feet shown, containing pebbles of chalk, etc.
II. Stratified gravel and sand (Westleton).
III. London Clay.
IV. Loamy sand—Basement Bed, London Clay.

N.B.—The junction of beds 2 and 3 was hidden by talus. The section is drawn from a rough sketch and was about 30 feet in depth.

A short examination showed that it is composed mainly of flint pebbles, derived no doubt for the most part from the wreck of Tertiary pebble-beds; subangular flints are fairly common, as also are quartz pebbles. I noticed several pebbles of whitish quartzite, one of which measured 5 inches in longest diameter. The gravel was clearly stratified.

Assuming, therefore, that we have here the Westleton Beds of Prestwich, the point to which I wish to draw attention is the manner in which the section illustrates their relation to the Chalky Boulder-clay. This sufficiently appears from the above sketch. The Boulder-clay rests against the Westleton Bed in the north of the pit, but has cut through it on the south, and lies directly on London Clay. A very similar section on the railway between Chapple and Mark's Tey is given by Prestwich, fig. 7, at p. 132 of the paper mentioned above.

V.—Note on a Table of Contemporary Geological Deposits arranged Stratigraphically, with their Characteristic Genera of Mammalia.

By Dr. C. I. Forsyth-Major, Corr. Memb. Zool. Soc. Lond.

THE subjoined list of characteristic genera of Mammalia has been compiled, at the request of my friend Dr. Henry Woodward, for the purpose of being used as a descriptive Table to be fixed on the wall of the Mammalian Gallery in the Geological Department of the British Museum (Natural History), and has been arranged in the form which was thought to be most suitable for the purpose.

I have only a few remarks to offer with regard to some points in which I have given expression to views not in accordance with those generally accepted.

In assigning the deposits of Pikermi, Mont Léberon, Samos, Maragha, etc., to the Upper Miocene rather than to the Lower Pliocene, as advocated by the majority of palæontologists, I am not aware that the considerations which formerly led me to hold this view have since been invalidated. At the locality Raphina, near the sea-shore, about four miles from Pikermi, Th. Fuchs came upon layers intercalated with the deepest strata of the Pikermi formation and containing the following shells: *Ostræa edulis*, *Spondylus gæderopus*, *Cerithium*, *Balanus*, all of which still live in the adjoining sea, and present a very recent aspect ("das äussere Ansehen dieser Fossilien ist äusserst jugendlich, wie quaternär"). Fuchs considers them to be contemporaneous with the Pikermi formation; as it was impossible, however, to collocate the latter with the Pleistocene, he resorted to a sort of compromise by assigning both to a very recent Pliocene. None of the palæontologists who have studied the fauna of Pikermi, Maragha, Mont Léberon, Samos, etc., could arrive at a similar conclusion; but in order to reconcile the two seemingly conflicting occurrences, a further compromise was resorted to, and Pikermi, etc., became 'Lower Pliocene.' The shells being, however, undoubtedly Pleistocene, the only possible explanation is the one given by De Stefani, viz., that their intercalation with the Pikermi formation is the result of a secondary *remaniement* of this latter by the sea. I think that better arguments than those deduced from the presence of the Raphina shells ought to be brought forward, if the Pikermi and allied formations are to be maintained in the Lower Pliocene.

With regard to the classification of the Jurassic Mammalia as '?Monotremata,' I have to offer the following explanation:—Part of them, the Multituberculata (Allotheria), are considered by some authors to have affinities with the Monotremata, and are consequently placed in the same subclass, 'Prototheria,' with the latter, whilst others prefer to assign them to a distinct suborder, collocated between the Monotremata and Marsupialia. The majority of Mesozoic remains, those provided with numerous teeth, are by almost common consent united with the Polyprotodont Marsupialia. With regard to the latter point, it has been observed by Winge that the simple forms of the teeth and their large number in *Myrmecobius*, several Edentates and Cetacea, are not a primitive character, but the consequences of a sort of degeneration; and further, that the shape of the posterior part of the mandible in the Triconodontidæ is quite different from that in Marsupialia. Besides, there is some ground for the assumption that the Marsupialia are merely an outcome of the Placentalia.

Therefore, with regard to the Jurassic 'Mammals' generally, since their mammalian nature has not yet been raised beyond every doubt, it seemed more prudent to include them all under the head of the subclass or order which presents more affinities with the Reptilia than do the *Marsupialia or Placentalia.*

SYSTEM.	PROBABLE CONTEMPORARY DEPOSITS.	CHARACTERISTIC GENERA OF MAMMALIA.
PLEISTOCENE.	**Peat; Alluvium; Loess.** **Valley-gravels; Brickearths.** **Cave-deposits; Raised beaches.**	Proboscidea.—Mastodon, Elephas. Perissodactyla.—Rhinoceros, Elasmotherium, Equus. Artiodactyla. — Hippopotamus, Sus, Phacochœrus; Moschus, Cervus, Cervalces, Alces, Rangifer, Capreolus; Saïga, Rupicapra, Gazella, Oreas, Cobus, Boselaphus; Ovibos; Bubalus, Bison, Bos; Capra, Ovis; Camelopardalis (Libytherium). Sirenia.—Rhytina. Rodentia.—Prolagus, Lagomys, Sylvilagus, Lepus; Castor, Trogontherium, Sciurus, Arctomys, Spermophilus; Myoxus, Muscardinus; Pellegrinia; Hystrix, Sminthus, Alactaga, Siphneus, Ellobius, Spalax, Cricetus, Myodes, Microtus, Mus. Chiroptera. Rhinolophus, Plecotus, Vespertilio, Vesperugo. Carnivora.—Ursus; Canis, Cyon; Hyæna; Meles; Herpestes, Gulo, Mustela, Putorius; Felis, Machairodus. Primates.—Macacus; Homo.
	Cave deposits, Peat, Lacustrine deposits (Madagascar).	Artiodactyla.—Potamochœrus, Hippopotamus. Rodentia.—Brachyuromys, etc. Insectivora.—Centetes, Oryzoryctes, Microgale. Primates. — Megaladapis, Archæolemur, Dinolemur, Thaumastolemur, Globilemur; Nesopithecus.
LOWER PLEISTOCENE.	**Forest Bed (Norfolk Coast).** **Saint-Prest; Durfort, etc.—(France).** **Leffe; Arezzo; Rome—(Italy).** **Equus and Megalonyx Beds (U.S.A.).**	Edentata.—Megalonyx, Mylodon, Glyptodon, Chlamydotherium. Proboscidea.—Elephas, Mastodon. Perissodactyla.—Tapirus; Rhinoceros, Equus. Artiodactyla.—Hippopotamus, Dicotyles, Sus; Cervus, Cariacus, Capreolus, Alces; Gazella, Bubalus, Bison, Bos; Camelus, Camelops, Eschatius, Auchenia. Rodentia.—Prolagus, Lagomys, Lepus; Trogontherium, Castor, Castoroides; Sciurus, Arctomys; Erethizon, Hydrochœrus; Thomomys, Geomys; Zapus; Neotoma, Microtus, Mus. Insectivora.—Talpa, Scalops; Myogale; Sorex, Crossopus, Crocidura. Carnivora. — Procyon, Arctodus; Ursus, Canis, Cyon, Urocyon; Hyæna; Mustela, Lutra, Mephitis; Arctotherium, Felis, Machairodus. Primates.—Macacus; Homo.

LOWER PLEISTOCENE.	**Pampas Formation (S. America).**	Marsupialia.—Didelphys, Dimerodon. Edentata.—Myrmecophaga; Megatherium, Mylodon, Pseudolestodon, Lestodon, Scelidotherium, Platyonyx, Glossotherium; Glyptodon, Hoplophorus, Panochthus, Dœdicurus; Chlamydophorus, Dasypotherium, Chlamydotherium, Tatusia, Tolypeutes, Xenurus. Proboscidea.—Mastodon. Perissodactyla.—Toxodon, Dilobon ('Toxodontia'); Typotherium, Pachyrucos ('Typotheria'); Hippidium, Equus; Macrauchenia; Tapirus. Artiodactyla.—Dicotyles; Cervus, Coassus; Auchenia, Mesolama, Palæolama, Protauchenia. Rodentia.—Sylvilagus; Myopotamus, Ctenomys, Dicœlophorus, Pithanotomys, Schizodon, Loncheres, Cavia, Hydrochœrus, Lagostomus; Hesperomys, Habrothrix, Nectomys, Rheithrodon, Holochilus. Primates.—Homo.
	Central Australia.	Monotremata.—Proëchidna. Marsupialia.—Pseudochirus, Dasyurus, Thylacinus, Thylacoleo, Pseudochirus, Koalemus; Macropus, Sthenurus, Procoptodon, Palorchestes, Diprotodon, Nototherium; Phascolomys, Phascolonus. Carnivora.—Canis.
UPPER PLIOCENE.	**Upper Siwaliks (India).** **Pithecanthropus Beds, Trinil (Java).** **Borneo.** **Kos (Asia Minor).** **Red Crag, partim (Suffolk and Essex).** **Montpellier, partim; Perrier; Ardé; Coupet—(France).** **Astigiano; Upper and Lower Val d'Arno; Olivola—(Italy).** ? **Blanco (U.S.A.).**	Edentata.—Manis. Proboscidea.—Elephas, Mastodon. Perissodactyla.—Tapirus; Rhinoceros; Equus. Artiodactyla.—Hippopotamus; Platygonus, Sus; Probubalus, Amphibos, Bubalus; Leptobos, Bison, Bos; Camelopardalis; Boselaphus, Tragelaphus, Palæoryx; Capra; Cervus; Pliauchenia. Rodentia.—Lagomys, Caprolagus; Castor; Hystrix; Microtus, Nesokia. Carnivora.—Ælurus, Ursus, Canis, Viverra, Hyæna, Lepthyæna; Mellivora, Mustela, Enhydriodon, Lutra; Machairodus, Felis. Primates.—Macacus, Semnopithecus; Pithecanthropus.

SYSTEM.	PROBABLE CONTEMPORARY DEPOSITS.	CHARACTERISTIC GENERA OF MAMMALIA.
LOWER PLIOCENE.	Siwaliks, partim (India). Eppelsheim (Germany). Casino (Tuscany). Montpellier, partim; Roussillon—(France). Alcoy (Spain). Red and Coralline Crags (England), partim. Antwerp Crag (Belgium). ? Blanco (U.S.A.).	PROBOSCIDEA.—Dinotherium, Mastodon. PERISSODACTYLA.—Rhinoceros; Tapirus; Hipparion, Hippidium. ANCYLOPODA.—Chalicotherium. ARTIODACTYLA.—Hippopotamus (Hexaprotodon), Sus; Hyæmoschus; Palæoryx, Gazella; Cervus, Capreolus; Phauchenia. INSECTIVORA.—Talpa, Crocidura. RODENTIA.—Prolagus, Caprolagus; Castor; Ruscinomys; Rhizomys, Trilophomys. CETACEA.—Squalodon; Eurhinodelphis, Priscodelphinus, Schizodelphis; Globicephalus; Tursiops, Orca; Physeter; Hoplocetus, Hyperoodon, Choneziphius, Dioplodon, Berardiopsis, Plesiocetus, Isocetus, Balænoptera, Megaptera, Balæna. SIRENIA.—Halitherium (Felsinotherium). CARNIVORA FISSIPEDIA.—Hyænarctos, Ursus; Hyæna, Viverra; Simocyon, Vulpes; Machairodus, Caracal, Felis. CARNIVORA PINNIPEDIA.—Pristiphoca, Monatherium, Palæophoca, Mesotaria, Callophoca. PRIMATES.—Semnopithecus, Macacus, Dolicopithecus, Cynocephalus, Anthropopithecus.
? LOWER PLIOCENE.	Araucanian Formation, Monte Hermoso (Argentina).	MARSUPIALIA.—Didelphys. EDENTATA.—Lestodon, Megatherium, Scelidotherium, Pseudolestodon; Glyptodon, Hoplophorus, Panochthus, Neuryurus; Chlamydotherium, Dasypus, Dasypotherium, Proeuphractus. UNGULATA.—Toxodon, Trachythærus; Protypotherium, Typotherium; Tapirus; Hippidium, Macrauchenia, Epitherium; Auchenia, Eoauchenia, Paraceros. RODENTIA.—Myopotamus, Tribodon, Eumysops, Pithanotomys, Megamys, Microcavia, Palæocavia, Hydrochœrus. CARNIVORA.—Canis.

UPPER MIOCENE.	**Siwaliks, partim (India).** **Maragha (Persia).** **Samos (Asia Minor).** **Pikermi (Attica).** **Baltavar (Hungary).** **Belvedere (Austria).** **Monte Bamboli; Casteani—(Tuscany).** **Mont Léberon; Croix-Rousse, etc.—(France)** **Concud (Spain).** **Loup Fork (U.S.A.).**	PROBOSCIDEA.—Dinotherium, Mastodon. EDENTATA.—Orycteropus. PERISSODACTYLA.—Hyrax; Aceratherium, Teleoceras, Aphelops; Tapiravus; Anchitherium, Hipparion, Protohippus. ANCYLOPODA.—Chalicotherium. ARTIODACTYLA.—Hippohyus, Sus; Sivatherium, Bramatherium, Helladotherium, Palæotragus, Samotherium; Tragoceros, Criotherium, Bucapra; Palæoryx, Protoryx, Helicophora, Prostrepsiceros, Gazella; Blastomeryx, Cervus. RODENTIA.—Panolax; Eucastor; Hystrix; Hesperomys, Acanthomys. CHIROPTERA.—Vespertilio. CARNIVORA.—Hyænarctos, Leptarctos; Ælurodon, Simocyon; Hyænictis, Ictitherium, Hyæna, Lycyæna; Promeles, Promephitis; Lutra, Brachypsalis. PRIMATES.—Mesopithecus, Oreopithecus.
? UPPER MIOCENE.	**Patagonian Formation (Argentina).**	MARSUPIALIA.—Apera, Cynonasua. EDENTATA.—Promegatherium, Interodon, Promylodon, Nephrotherium; Hoplophorus, Protoglyptodon; Proeuphractus, Chlamydotherium. UNGULATA.—Toxodon, Protypotherium; Proterotherium; Scalabrinotherium; Macrauchenia. RODENTIA.—Discolomys, Morenia, Eucardiodon, Lagostomus, Megamys, Briaromys. CETACEA.—Pontistes, Pontivaga, Balæna, Notiocetus. SIRENIA.—Ribodon.
MIDDLE MIOCENE.	**Dinotherium Sands [Georgensgmünd, Steinheim, Nördlingen, Günzburg] (Germany).** **Sansan, St. Gaudens, Grive St. Alban—(France).** **San Isidro (Spain).** **(Not represented in N. America.)**	PROBOSCIDEA.—Dinotherium; Mastodon (angustidens). PERISSODACTYLA.—Aceratherium, Rhinoceros; Anchitherium. ANCYLOPODA.—Macrotherium. ARTIODACTYLA.—Listriodon, Hyotherium; Dicrocerus, Palæomeryx, Procervulus, Micromeryx. RODENTIA.—Titanomys, Prolagus, Lagopsis; Steneofiber, Xerus, Sciuropterus, Sciurus; Myoxus; Cricetodon. INSECTIVORA.—Galerix; Lantanotherium, Myogale; Talpa; Sorex; Dimylus. CHIROPTERA.—Pteropus; Vespertilio. CARNIVORA.—Amphicyon, Hemicyon, Dinocyon; Hyænarctos, Ursus (?); Palæogale, Stenogale; Trochictis, Trochotherium; Pseudælurus. PRIMATES.—Dryopithecus; Pliopithecus.

SYSTEM.	PROBABLE CONTEMPORARY DEPOSITS.	CHARACTERISTIC GENERA OF MAMMALIA.
? MIDDLE MIOCENE.	**Santa Cruz Formation (Argentina).**	MARSUPIALIA (incl. 'SPARASSODONTIA'). — Microbiotherium, Prodidelphys, Eodidelphys, Stylognathus, Prothylacinus, Abderites, Acdestis, Epanorthus, Callomenus, Garzonia ; Borhyæna, Hathlyacynus, Dinamyctis, Conodynictis, Cladosictis, Amphiproviverra. EDENTATA.—Hapalops; Pseudhapalops, Hyperleptus, Pelecyodon; Prepotherium; Planops ; Analcitherium ; Asterostemma ; Prodasypus ; Peltephilus. UNGULATA.—Protypotherium, Icochilus ; Pachyrucos ; Nesodon ; Acrotherium ; Adiantus, Theosodon ; Proterotherium, Licaphrium ; Diadiaphorus, Astrapotherium ; Homalodontotherium. RODENTIA.—Steiromys, Acaremys ; Neoreomys, Perimys ; Eocardia, Procardia, Dicardia. ? INSECTIVORA.—Necrolestes. PRIMATES.—Homunculus, Anthropops.
LOWER MIOCENE (? UPPER OLIGOCENE).	**Weisenau n. Mayence; Ulm—(Germ.).** **St. Gérand-le-Puy ; Calcaire de Beauce —(France).** **Schio strata, Belluno (Italy).** **John Day Beds (Western N. America).**	MARSUPIALIA.—Oxygomphius, Didelphys. AMBLYPODA.—Moropus. PERISSODACTYLA.—Diceratherium ; Tapirus ; Aceratherium. ARTIODACTYLA. — Elotherium ; Merycochœrus, Merychyus, Palæochœrus ; Agriochœrus ; Dremotherium, Cænotherium ; Plesiomeryx (gracilis) ; Gomphotherium. RODENTIA.—Titanomys, Palæolagus ; Allomys ; Archæomys, Theridomys, Issiodoromys ; Pleurolicus, Entoptychus ; Hesperomys, Cricetodon. INSECTIVORA.—Plesiosorex ; Talpa. CARNIVORA.—Hyænodon ; Amphicyon ; Temnocyon ; Hyænocyon, Enhydrocyon ; Palæogale ; Potamotherium ; Proælurus, Hoplophoneus, Nimravus. SIRENIA.—Halitherium (bellunense).
		MARSUPIALIA.—Polydolops, Epanorthus ; Proborhyæna, Pharsophorus. EDENTATA PRIMITIVA.—Notostylops, Anastylops, Parastylops. EDENTATA.—Orophodon, Hapalops ; Palæopeltis ; Proeutatus ; Peltephilus. ? CONDYLARTHRA.—Didolodus ; Propteriptychus.

OLIGOCENE.	**Hempstead (Isle of Wight).** **Phosphorites. part. ; Ronzon (France).** **Rochette (Switzerland).** **Cadibona ; Zovencedo—(Italy).** **White River Beds (Western North America).**	Marsupialia.—Amphiperatherium, Didelphys. Perissodactyla. — Titanotherium, Metamynodon ; Aceratherium, Leptaceratherium ; Lophiodon, Helaletes, Colodon ; Mesohippus. Artiodactyla. — Elotherium ; Oreodon, Agriochœrus ; Anthracotherium ; Protoceras ; Gelocus ; Plesiomeryx, Leptomeryx ; Poëbrotherium. Rodentia.—Palæolagus ; Ischiromys ; Theridomys ; Steneofiber ; Gymnoptychus ; Eumys, Cricetodon. Insectivora.—Ictops, Leptictis. Chiroptera.—Domnina. Carnivora. — Hyænodon ; Cynodon, Daphænus ; Plesictis, Hoplophoneus, Dinictis. Sirenia.—Halitherium (H. Schinzi, H. Chouqueti). Primates.—Laopithecus, Menotherium.
UPPER EOCENE.	**Bembridge (Isle of Wight) ; Hordwell (Hants).** **Gypsum of Montmartre (Paris).** **Sands of Beauchamps (France).** **French Phosphorites (partim).** **Lignites of Débruge (Vaucluse).** **Bohnerz of Switzerland and South Germany : Egerkingen, Mauremont, Delsberg ; Fronstetten, Ulm, Heidenheim, Pappenheim (partim).** **Monte Zuello (Italy).** **Uinta Formation ; Arkansas ; Alabama —(U.S.A.).**	Marsupialia.—Didelphys. Cetacea.—Zeuglodon. Sirenia.—Halitherium (veronense). Amblypoda.—Uintatherium. Perissodactyla. — Palæotherium, Lophiotherium, Anchilophus, Lophiodon, Protapirus, Schizotherium, Cadurcotherium ; Telmatotherium, Amynodon, Diplacodon, Triplopus, Epihippus, Helaletes. Artiodactyla.—Anoplotherium, Diplobune ; Dichobune, Gelocus, Plesiomeryx (cadurcense), Xiphodon ; Chœropotamus ; Leptotragulus, Protoreodon, Elotherium. Rodentia.—Pseudosciurus, Sciuroides, Theridomys, Trechomys, Eomys ; Paramys, Protoptychus. Insectivora.—Amphidozotherium, Neurogymnurus. Chiroptera.—Vespertiliavus, Hipposideros. Creodonta.—Pterodon, Hyænodon, Proviverra, Cynohyænodon, Quercytherium ; Mesonyx. Carnivora.—Cynodictis, Cynodon, Plesiocyon, Cephalogale, Pseudamphicyon, Stenoplesictis, Palæoprionodon, Palæogale, Amphictis, Pseudælurus. Primates.—Adapis, Microchœrus, Cænopithecus, Cryptopithecus ; Hyopsodus, Microsyops.

SYSTEM.	PROBABLE CONTEMPORARY DEPOSITS.	CHARACTERISTIC GENERA OF MAMMALIA.
MIDDLE EOCENE.	**Bracklesham (Sussex).** **Egerkingen and Mauremont (Switzerland, partim).** **Argenton ; Issel—(France).** **Buchsweiler (Alsace).** **Bridger Formation (Wyoming, North America).** **Jamaica (Limestone).**	Marsupialia.—Didelphys. Sirenia.—Prorastomus, Halitherium. Amblypoda.—Dinoceras, Uintatherium, Tinoceras. Perissodactyla.—Lophiodon, Palæotapirus. Paloplotherium, Pachynolophus, Hyracotherium ; Lambdotherium, Helaletes, Hyrachyus, Palæosyops, Limnosyops. Artiodactyla.—Dichobune ; Achænodon, Homacodon. Rodentia.—Paramys, Tillomys. Insectivora.—Ictops. Chiroptera.—Nyctilestes, Nyctitherium. Creodonta.—Mesonyx, Proviverra, Protopsalis, Miacis, Didymictus, Patriofelis. Primates.—Hyopsodus, Tomitherium, Omomys, Notharctus, Limnotherium, Microsyops.
LOWER EOCENE.	**London Clay.** **Paris Basin.** **Egerkingen, Switzerland (partim).** **Wasatch Formation (North America).**	Marsupialia.—Didelphys. Condylarthra.—Phenacodus, Protogonia, Meniscotherium. Perissodactyla.—Hyracotherium, Pachynolophus, Lophiodon, Eohippus, Heptodon, Systemodon. Artiodactyla.—Pantolestes, Lophiodochœrus, Protodichobune. Amblypoda.—Coryphodon, Ectacodon. Tillodontia.—Esthonyx. Rodentia.—Paramys, Decticadapis. Insectivora.—Diacodon, Centelodon. Creodonta.—Proviverra, Cynohyænodon, Pachyæna, Amblyctonus, Didelphodus. Carnivora.—Palæonyctis, Oxyæna. Primates.—Hyopsodus, Lemuravus, Tomitherium, Microsyops, Anaptomorphus.

BASE OF EOCENE.	**Cernay Conglomerates ; La Fère—(France).** **Torrejon (New Mexico).** **Puerco (New Mexico).**	Allotheria.—*Neoplagiaulax, Liotomus ; Catopsalis, Polymastodon, Ptilodus, Chirox.* Edentata.—Hemiganus, Psittacotherium, Onychodectes, Conoryctes. Condylarthra. — Pleuraspidotherium, Orthaspidotherium ; Protogonodon, Euprotogonia, Periptychus, Anisonchus, Hemithlæus, Haploconus, Mioclænus, Protoselene. Amblypoda.—Pantolambda. Rodentia primitiva.—Plesiadapis, Protoadapis ; Mixodectes. ? Insectivora.—Adapisorex. Creodonta. — Procynictis, Dissacus, Hyænodictis, Protoviverra, Arctocyon ; Oxyclænus, Protochriacus, Chriacus, Tricentes, Deltatherium, Triisodon, Sarcothraustes, Microclænodon, Clænodon. ? Primates.—Indrodon.
UPPER CRETACEOUS.	**Ceratops Beds, Laramie (W. N. Amer.).**	Multituberculata incertæ sedis. (1) ? Monotremata. Plagiaulacidæ. — Cimolestes, Didelphops, Cimolomys, Pediomys, Ptilodus, Meniscoëssus, Allacodon. (2) Synconodon, Ectoconodon, Protolambda.
JURASSIC.	**Purbeck Beds (Dorsetshire) ; Stonesfield Slate (Oxfordshire).** **Atlantosaurus Beds, Colorado, etc. (Western N. America).**	? Monotremata. Triconodontidæ.—Phascolotherium, Triconodon, Spalacotherium. Amphilestidæ.—Amphilestes, Dicrocynodon, Docodon. Amblotheriidæ.—Dryolestes, Amblotherium, Asthenodon. Plagiaulacidæ (Multituberculata).—Plagiaulax, Ctenacodon, Allodon, Bolodon.
TRIAS.	**Frome (Somersetshire).** **Echterdingen (Würtemberg).** **Conn. River Beds (N. America).**	? Microlestes. ? Dromatherium, ? Microconodon.

NOTICES OF MEMOIRS.

I.—THE ACTION OF WAVES AND TIDES ON THE MOVEMENT OF MATERIAL ON THE SEA-COAST. By W. H. WHEELER, M.Inst.C.E., Boston, Lincolnshire.[1]

THE object of this paper is to show the relative effect of waves due to wind and tidal action on littoral drift. It is pointed out that all cliffs that border the sea-coast are doomed to erosion, and the material derived from their destruction, after being sorted and prepared by waves and tidal action, is conveyed to the depths of the sea. The function of wind waves is to break down the cliffs, to sort the material displaced, and to reduce the larger rock fragments into sizes sufficiently small to be acted on by the tides, and to disperse material that has been collected in large masses by tidal action. The function of the tides consists in raising the water of the ocean sufficiently high to enable the waves to attack the cliffs, in assisting in the grinding up of the reduced rock fragments by their perpetual oscillating motion until sufficiently reduced in size, and then in transporting them to the bed of the sea, the latter operation being effected either in solution, suspension, or rolling along the bottom.

It is shown that all material eroded from the cliffs is ultimately carried seaward, and that the sea yields nothing to the land. The only agents capable of transporting material of greater specific gravity than the water are the waves, and their action, until they break on the shore, is merely one of undulation; and therefore it is only the stones, shingle, or sand which lie shorewards of the point where the wave breaks that can be carried forward on to the beach. On the other hand, the slope of the beach being seawards, all material has a natural tendency to work downwards under the action of gravity, this downward action being aided by the undertow of the retiring shore waves.

Material eroded from the cliffs consists of rock fragments, boulders, sand, and alluvium. The alluvium, consisting of particles of sufficient minuteness to remain in suspension for a considerable time, is diffused by the waves over a very considerable distance, and is finally deposited in the deep part of the ocean; the sand is gradually worked down the beach by the action of the waves and tides, and is also spread over the sea bed, but nearer to the shore; the rock fragments are reduced to shingle small enough to be acted on by the tides, and in this condition are rolled up and down the beach and drifted along the coast until ground into particles sufficiently fine to be transported to the sea. Shingle is generally accumulated in banks in the zone lying between low-water of neap tides and high-water of spring tides, and travels along the coast in one given direction. The heaping up and travel of the shingle is due to tidal action. The effect of wind waves due to gales is principally destructive to shingle banks, cutting out and dispersing the material, the banks being restored by tidal action in calm weather and during offshore winds. The action of waves due to wind is intermittent, variable in direction, and irregular. The travel of shingle, except when acted on by gales, is continuous, regular, and constant in direction. It is shown by a number of examples that the travel of shingle is not coincident either with the prevailing or predominant winds, but on a tidal coast the predominant drift is invariably in the same direction as that of the flood tide. The action of the tides in heaping up and drifting material is due to wave action. The rise and fall of the tide on the coast does not consist of a mere vertical rise and fall of the water, but of a continual oscillation. The crest of the tidal wave in the open sea, being in advance of that near the shore, results in an oblique lateral movement along the beach, and the advance of the water being checked by the shallow bed with which it comes in contact, is reflected back, resulting in a series of small oscillations or waves which break when they reach the low-water line. These oscillations are ever present on the margin of the shore, even when the sea is calmest, and are never absent except when absorbed by larger waves due to gales. These tidal wavelets vary in height from 6 inches to 2 feet, and break on the shore at the rate of from ten to twenty a minute according to the rise of the tide and the slope of the beach. These wavelets, aided by the flood current, lift up and carry forward any coarse sand, loose stones, or other material with which they come in contact, and leave some portion of it stranded at the highest point to which the tide of the day reaches. The wavelets, besides lifting and transporting the shingle, brush upward the whole of the face of the bank, and gradually raise it above the line of high-water. It is shown that, though these waves are small, they by their weight and velocity develop sufficient force to move a large quantity of pebbles. A wave having a height of only a foot from trough to crest, giving a head of 6 inches, and containing a volume of water equal to a weight of ·142 ton has sufficient kinetic energy to raise 165 lbs. of pebbles a foot high. Allowing the weight of pebbles in water to be 100 lbs. to the cubic foot, each wave, if the whole of its energy be applied to the movement of the material, is capable of raising 660 pebbles 2 inches in diameter a foot; or, with fifteen waves to the minute, 9,900 pebbles a minute and 2,376,000 in a single tide, or a total weight of stone of 266·4 tons a foot high. This, however, is beyond the work actually done, as a portion of the energy of the wave is absorbed in friction. The above rough approximation of the power of the wavelets is sufficient to show the enormous power that is developed by tidal action day by day on the coast, and the capability of the wavelets due to the tides for building up shingle banks and drifting the pebbles along the beach.

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[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

II.—LEADHILLITE IN ANCIENT LEAD SLAGS FROM THE MENDIP HILLS.[1] By L. J. SPENCER, M.A., F.G.S., British Museum (Natural History).

LEAD ores have been worked in the Mendip Hills (East Somerset) ever since the time of the Romans; but during the present century operations have been chiefly confined to the reworking of the old waste heaps of slags and slimes. From these heaps upwards of 9,000 tons of lead was extracted during the ten years ending 1880. The material now being worked at Priddy has the appearance of a brown earth: it contains fragments of charcoal and limestone, and about 6 per cent. of lead as carbonate. Embedded here and there in this material are blocks consisting of devitrified slag, partially fused galena, and fragments of charcoal; and in the cavities numerous small crystals of cerussite ($Pb\,C\,O_3$) and anglesite ($Pb\,S\,O_4$) and, less frequently, of leadhillite.

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Leadhillite has not been before observed under such conditions. In the Roman lead slags at Laurion in Greece, which have been in contact with sea-water, Lacroix has noted the following secondary minerals: matlockite, penfieldite, laurionite, fiedlerite, phosgenite, cerussite, hydrocerussite, and anglesite.

The colourless crystals of Mendip leadhillite have, perpendicular to the perfect basal cleavage, an acute negative bisectrix with an optic axial angle in air of $2E = 72\frac{3}{4}°$; at a temperature of 97° C., $2E = 70\frac{1}{2}°$. The frequent twinning and the goniometric measurements (which are, however, not very good) are not inconsistent with the orthorhombic symmetry insisted upon by Miller. The basal planes of complicated twin crystals always give a single sharp reflected image, which is not the case with twin crystals of ordinary monosymmetric leadhillite. A few crystals are optically uniaxial.

There therefore seem to be three kinds of leadhillite, all of which are identical in outward appearance: (*a*) Monosymmetric, with the optic axial angle $2E = 20°$; (*b*) rhombohedral (?) and optically uniaxial (susannite): (*c*) orthorhombic, with $2E = 72\frac{3}{4}°$.

Before 1874 the formula for leadhillite was given as $PbSO_4.3PbCO_3$, and that now usually accepted is $PbSO_4.2PbCO_3.Pb(OH)_2$; but no two of the several analyses that have been made are in close agreement, and other formulæ have been proposed. Doubtless each of the above kinds has a definite chemical composition, and the variations shown by the different analyses are possibly due to the fact that two—(*a*) and (*b*) or (*b*) and (*c*)—of the three kinds may occur together in the same crystal, as observed by Bertrand and by myself in specimens from Leadhills. It will therefore be necessary to examine optically each fragment that is collected for future analyses of leadhillite.

III.—Gigantic Irish Deer-Remains.—Report of the Committee, consisting of Professor W. Boyd Dawkins (Chairman), His Honour Deemster Gill, the Rev. E. B. Savage, Mr. G. W. Lamplugh, and Mr. P. M. C. Kermode (Secretary), appointed to examine the Conditions under which remains of the Gigantic Irish Deer are found in the Isle of Man.[1]

We were able to add a footnote to our report of last year to the effect that a fairly perfect skeleton of *Cervus giganteus* had been discovered, of which we hoped to hand in details with this year's report. These remains were found in a marl-pit at Close-y-

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[1] *Communicated* to the British Association, Bristol, September, 1898, Section C (*Geology*).

Garey, on the east side of the railway line, half a mile north from St. John's, and the same distance south from Poortown station.

The bones were nearly all in juxtaposition and, excepting the ribs and pelvic bones and one shoulder-blade, in a very fair state of preservation. The antlers were nearly complete; the beams, however, are represented by fragments, the skull also is fragmentary.

The left antler is the larger; it measures across the palm 15 inches, allowing for a piece of the front edge which has decayed away; the right measures 13 inches. With the tines, most of which dropped off on lifting from the marl, they are respectively 56½ inches and 53 inches long, and the beam would have been about 10 inches more. They show six points, besides the brow-tines, which had fallen off, the portion of the beam to which they were attached having decayed away.

The palm of the left antler lay over the lumbar vertebræ, and the right over the fore-quarters. The upper jaw teeth were preserved on both sides, and those of the left lower jaw were embedded in the ramus. A fragment of the right symphysis was also present, and there were various fragments of a skull which had been broken up before the discovery.

One of the ribs had been perforated, probably by the point of an antler of another elk in one of their usual fights. It was fractured as well as perforated, and had been healed. This injury, therefore, was not connected with the death of the animal, which took place in its full prime, as shown by the perfection of the teeth and the dimensions of the antlers.

Professor Boyd Dawkins examined the bones in December and made the measurements of the skeleton found at Close-y-Garey.

Excavation No. 1 in disturbed soil yielded fragments of upper jaw (teeth worn) of *Cervus giganteus.*

The skeleton lay in white marl at a depth of about 9 feet from the present surface, on its right side, the legs drawn up to the body, the head towards the margin of the ancient pool, now a morass, which lies in a hollow in the glacial drifts.

From the position of the bones the animal appeared to have died where it was found, not to have been washed down by floods. About sixty years ago the bog had been worked for marl, and the present well-defined banks mark out a rectangular hollow some 50 yards square and about 3 feet below the surrounding surface.

Across one corner of this a trench was dug to carry off the water, and the operations of the Committee were confined to a triangular area on the west side of the trench, measuring about 15 yards east and west, by about 30 yards north and south. They excavated all over this space to a depth of over 9 feet. The first four excavations, being through ground which had previously been disturbed, yielded no definite results, but at one point a few bones were met with, among which were fragments of maxilla, the sixth cervical vertebra, the second lumbar vertebra, and a fragment of a rib. In association with these were remains of horse represented by a radius *and lower jaws of two* individuals. Though the ground had been disturbed the horse bones probably belonged to the same age as the Great Deer. A fragment of a metatarsal, met with in digging the trench, had an artificial perforation.

The result of all the excavations, allowing for the disturbed state of the ground, showed the following beds :—

	Ft.	in.
A. Disturbed soil and peat, an average of about ...	3	0
B. In one place a blue clay or silt was observed resting on the white marl.		
C. White marl containing the remains of the Gigantic Deer ...	6	6
D. Blue marl[1] ...	1	0
E. Red sand with gravel ...	0	3
F. Brown clay ...	0	3
G. Sand and gravel } ? Glacial drift ...	0	3
H. Clay ... } ? Glacial drift ...	4	0

As stated above, the whole surface had been lowered about 3 feet in digging for marl; the peat had for the most part been removed, and a great deal of the marl also; indeed, we were fortunate in finding this one spot in which the marl itself had not been disturbed.

The finding of detached bones shows that other individuals had perished here, and is consistent with what we were told, that a specimen had been seen when digging for marl, and that the antlers of another had been taken out. We were told also that two skulls without antlers had been seen on the other side of our trench.

Samples of the marl and other beds were forwarded to Mr. James Bennie, of Edinburgh, who again most kindly undertook the laborious task of washing and sifting the material. The organic remains thus obtained were examined by Mr. Clement Reid, who has determined the following plants :—

From Peat B.

Ranunculus flammula, L.
Viola palustris, L.
Rubus fruticosus, L. (very small).
Potentilla tormentilla, Neck.
,, *comarum*, Nestl.
Carduus crispus, L.
Menyanthes trifoliata, L.
Empetrum nigrum, L.
Potamogeton, sp.
Carex, 4 sp.

Also beetles, 3 sp., and caddis cases.

From Marl C.

Ranunculus repens, L.
Viola palustris, L.
Potentilla comarum, Nestl.
Myriophyllum spicatum, L.
Rumex obtusifolius, L.
Empetrum nigrum, L.
Potamogeton, sp.
Carex, 4 sp.
Chara, sp.
Umbelliferous plant (unripe).

From Red Sand D.

Plant-remains, not determined.

From Bed E.

Betula alba.
Potamogeton, sp.
Carex, sp.
Bracts of sedge.
Leaves (?).

Mr. R. Okell examined the White Marl for Diatoms, but found no trace. There are no fresh-water shells in it.

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[1] *This was noticed* below the skeleton, and may have been discoloured by the *decay of the body.*

In our last report we were able to announce the discovery in a previous excavation near Ballough of the Arctic crustacean *Lepidurus glacialis*, and accompanied by the Arctic willow *Salix herbacea* in a bed of silt occurring above *Chara*-marl, like that of the present section. In that locality, however, we did not succeed in finding elk-remains in the marl, probably on account of the limited character of our excavation, as we have every reason to believe that the skeleton now in Edinburgh Museum was obtained from that bed. In the present instance, though we have found the elk, it will be noticed that the section contains no trace of the Arctic fauna. This is greatly to be regretted, since—as was pointed out by Mr. C. Reid in our last report—the relation of this fauna to the bed containing the elk is a point of great theoretical importance. It is also important that the presence of the horse in the wild fauna of the Isle of Man should be placed beyond doubt by working in undisturbed ground. The same group of animals may be expected as that which occurs in the prehistoric strata of Ireland and England. Under these circumstances we propose to apply for a further grant to carry on explorations which will probably definitely settle these interesting questions.

The balance of the grant, renewed last year, was expended in the preliminary work of draining; further funds, which enabled the Committee to continue the work and to exhume the specimen which has now been set up in Castle Rushen, Isle of Man, were provided by the local Society, which also contributed the amount required for mounting the skeleton.

The best thanks of the Committee are due to Messrs. C. Reid, J. Bennie, and R. Okell for the valuable assistance they have rendered in the investigation.

IV.—SUPPLEMENTARY LIST OF BRITISH MINERALS.[1] By L. J. SPENCER, M.A., F.G.S., British Museum (Natural History).

DURING the forty years which have elapsed since the publication of Greg and Lettsom's "Manual of the Mineralogy of Great Britain and Ireland," a considerable number of species, variety and other names have been added to the list of minerals occurring in the British Isles. In 1858 Greg and Lettsom recognized 241 British species, but of these only 209 are given as numbered species by Dana in the sixth edition (1892) of his "System of Mineralogy." To this list may now be added 84 more, bringing the total number of British species up to 293, as compared with the total of 824 known mineral species recognized by Dana in 1892. Owing to the difficulty in some cases of defining a mineral species, to the uncertainty of some of the determinations, and to the fact that a systematic search through the whole of the literature has not yet been made, these numbers can only be considered approximate.

Some of the most notable additions are of minerals which have been detected by the microscopical examination of rock-sections,

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[1] Read *before Sect. C (Geology), British* Association, Bristol Meeting, Sept. 1898.

CHARACTERISTIC GENERA OF MAMMALIA.

PIALIA (incl. 'SPARASSODONTIA'). — Microbiotherium, Prodidelphys, Eodidelphys, Stylognathus, Prothylacinus, Abderites, Acdestis, Epanorthus, Callomenus, Garzonia; Borhyæna, Hathlyacynus, Dinamyctis, Conodynictis, Cladosictis, Amphiproviverra.
ATA.—Hapalops; Pseudhapalops, Hyperleptus, Pelecyodon; Prepotherium; Planops; Analcitherium; Asterostemma; Prodasypus; Peltephilus.
LATA.—Protypotherium, Icochilus; Pachyrucos; Nesodon; Acrotherium; Adiantus, Theosodon; Proterotherium, Licaphrium; Diadiaphorus, Astrapotherium; Homalodontotherium.
TIA.—Steiromys, Acaremys; Neoreomys, Perimys; Eocardia, Procardia, Dicardia.
CTIVORA.—Necrolestes.
TES.—Homunculus, Anthropops.

PIALIA.—Oxygomphius, Didelphys.
PODA.—Moropus.
SODACTYLA.—Diceratherium; Tapirus; Aceratherium.
DACTYLA. — Elotherium; Merycochœrus, Merychyus, Palæochœrus; Agriochœrus; Dremotherium, Cænotherium; Plesiomeryx (gracilis); Gomphotherium.
TIA.—Titanomys, Palæolagus; Allomys; Archæomys, Theridomys, Issiodoromys; Pleurolicus, Entoptychus; Hesperomys, Cricetodon.
TIVORA.—Plesiosorex; Talpa.
VORA.—Hyænodon; Amphicyon; Temnocyon; Hyænocyon, Enhydrocyon; Palæogale; Potamotherium; Proælurus, Hoplophoneus, Nimravus.
IA.—Halitherium (bellunense).

PIALIA.—Polydolops, Epanorthus; Proborhyæna, Pharsophorus.
ATA PRIMITIVA.—Notostylops, Anastylops, Parastylops.
ATA.—Orophodon, Hapalops; Palæopeltis; Proeutatus; Peltephilus.
YLARTHRA.—Didolodus; Propteriptychus.
BOSCIDEA PRIMITIVA.—Pyrotherium.
LATA. — Archæophylus, Prosotherium, Eutrachytherus; Archæohyrax, Argyrohyrax; Leontinia, Asmodeus, Isotemnus, Trimerostephanus; Parastrapotherium, Deuterotherium, Adiantus, Notohippus, Coresodon, Morphippus, Rhynchippus.

OLIGOCENE.	**Hempstead (Isle of Wight).** **Phosphorites, part.; Ronzon (France).** **Rochette (Switzerland).** **Cadibona; Zovencedo—(Italy).** **White River Beds (Western North America).**	Marsupialia.—Amphiporatherium, Didelphys. Perissodactyla.—Titanotherium, Metamynodon; Aceratherium, Leptaceratherium; Lophiodon, Helaletes, Colodon; Mesohippus. Artiodactyla.—Elotherium; Oreodon, Agriochœrus; Anthracotherium; Protoceras; Gelocus; Plesiomeryx, Leptomeryx; Poëbrotherium. Rodentia.—Palæolagus; Ischiromys; Theridomys; Steneofiber; Gymnoptychus; Eumys, Cricetodon. Insectivora.—Ictops, Leptictis. Chiroptera.—Domnina. Carnivora.—Hyænodon; Cynodon, Daphænos; Plesictis, Hoplophoneus, Dinictis. Sirenia.—Halitherium (H. Schinzi, H. Chouqueti). Primates.—Laopithecus, Menotherium.
UPPER EOCENE.	**Bembridge (Isle of Wight); Hordwell (Hants).** **Gypsum of Montmartre (Paris).** **Sands of Beauchamps (France).** **French Phosphorites (partim).** **Lignites of Débruge (Vaucluse).** **Bohnerz of Switzerland and South Germany: Egerkingen, Mauremont, Delsberg; Fronstetten, Ulm, Heidenheim, Pappenheim (partim).** **Monte Zuello (Italy).** **Uinta Formation; Arkansas; Alabama—(U.S.A.).**	Marsupialia.—Didelphys. Cetacea.—Zeuglodon. Sirenia.—Halitherium (veronense). Amblypoda.—Uintatherium. Perissodactyla.—Palæotherium, Lophiotherium, Anchilophus, Lophiodon, Protapirus, Schizotherium, Cadurcotherium; Telmatotherium, Amynodon, Diplacodon, Triplopus, Epihippus, Helaletes. Artiodactyla.—Anoplotherium, Diplobune; Dichobune, Gelocus, Plesiomeryx (cadurcense), Xiphodon; Chœropotamus; Leptotragulus, Protoreodon, Elotherium. Rodentia.—Pseudosciurus, Sciuroides, Theridomys, Trechomys, Eomys; Paramys, Protoptychus. Insectivora.—Amphidozotherium, Neurogymnurus. Chirortera.—Vespertiliavus, Hipposideros. Creodonta.—Pterodon, Hyænodon, Proviverra, Cynohyænodon, Quercytherium; Mesonyx. Carnivora.—Cynodictis, Cynodon, Plesiocyon, Cephalogale, Pseudamphicyon, Stenoplesictis, Palæoprionodon, Palæogale, Amphictis, Pseudælurus. Primates.—Adapis, Microchœrus, Cænopithecus, Cryptopithecus; Hyopsodus, Microsyops.

CHARACTERISTIC GENERA OF MAMMALIA.

PIALIA.—Didelphys.
A.—Prorastomus, Halitherium.
PODA.—Dinoceras, Uintatherium, Tinoceras.
ODACTYLA.—Lophiodon, Palæotapirus, Paloplotherium, Pachynolophus, Hyracotherium; Lambdotherium, Helaletes, Hyrachyus, Palæosyops, Limnosyops.
ACTYLA.—Dichobune; Achænodon, Homacodon.
TIA.—Paramys, Tillomys.
IVORA.—Ictops.
PTERA.—Nyctilestes, Nyctitherium.
ONTA.—Mesonyx, Proviverra, Protopsalis, Miacis, Didymictus, Patriofelis.
TES.—Hyopsodus, Tomitherium, Omomys, Notharctus, Limnotherium, Microsyops.

PIALIA.—Didelphys.
LARTHRA.—Phenacodus, Protogonia, Meniscotherium.
ODACTYLA.—Hyracotherium, Pachynolophus, Lophiodon, Eohippus, Heptodon, Systemodon.
ACTYLA.—Pantolestes, Lophiodochœrus, Protodichobune.
PODA.—Coryphodon, Ectacodon.
ONTIA.—Esthonyx.
TIA.—Paramys, Decticadapis.
IVORA.—Diacodon, Centelodon.
ONTA.—Proviverra, Cynohyænodon, Pachyæna, Amblyctonus, Didelphodus.
ORA.—Palæonyctis, Oxyæna.
TES.—Hyopsodus, Lemuravus, Tomitherium, Microsyops, Anaptomorphus.

BASE OF EOCENE.	**Cernay Conglomerates; La Fère—(France).** **Torrejon (New Mexico).** **Puerco (New Mexico).**	ALLOTHERIA.—Neoplagiaulax, Liotomus; Catopsalis, Polymastodon, Ptilodus, Chirox. EDENTATA.—Hemiganus, Psittacotherium, Onychodectes, Conoryctes. CONDYLARTHRA. — Pleuraspidotherium, Orthaspidotherium; Protogonodon, Euprotogonia, Periptychus, Anisonchus, Hemithlæus, Haploconus, Mioclænus, Protoselene. AMBLYPODA.—Pantolambda. RODENTIA PRIMITIVA.—Plesiadapis, Protoadapis; Mixodectes. ? INSECTIVORA.—Adapisorex. CREODONTA. — Procynictis, Dissacus, Hyænodictis, Protoviverra, Arctocyon; Oxyclænus, Protochriacus, Chriacus, Tricentes, Deltatherium, Triisodon, Sarcothraustes, Microclænodon, Clænodon. ? PRIMATES.—Indrodon.
UPPER CRETACEOUS.	**Ceratops Beds, Laramie (W. N. Amer.).**	MULTITUBERCULATA INCERTÆ SEDIS. (1) ? MONOTREMATA. PLAGIAULACIDÆ. — Cimolestes, Didelphops, Cimolomys, Pediomys, Ptilodus, Meniscoëssus, Allacodon. (2) Synconodon, Ectooonodon, Protolambda.
JURASSIC.	**Purbeck Beds (Dorsetshire); Stonesfield Slate (Oxfordshire).** **Atlantosaurus Beds, Colorado, etc. (Western N. America).**	? MONOTREMATA. TRICONODONTIDÆ.—Phascolotherium, Triconodon, Spalacotherium. AMPHILESTIDÆ.—Amphilestes, Dicrocynodon, Docodon. AMBLOTHERIIDÆ.—Dryolestes, Amblotherium, Asthenodon. PLAGIAULACIDÆ (Multituberculata).—Plagiaulax, Ctenacodon, Allodon, Bolodon.
TRIAS.	**Frome (Somersetshire).** **Echterdingen (Würtemberg).** **Conn. River Beds (N. America).**	? Microlestes. ? Dromatherium, ? Microconodon.

NOTICES OF MEMOIRS.

I.—The Action of Waves and Tides on the Movement of Material on the Sea-coast. By W. H. Wheeler, M.Inst.C.E., Boston, Lincolnshire.[1]

THE object of this paper is to show the relative effect of waves due to wind and tidal action on littoral drift. It is pointed out that all cliffs that border the sea-coast are doomed to erosion, and the material derived from their destruction, after being sorted and prepared by waves and tidal action, is conveyed to the depths of the sea. The function of wind waves is to break down the cliffs, to sort the material displaced, and to reduce the larger rock fragments into sizes sufficiently small to be acted on by the tides, and to disperse material that has been collected in large masses by tidal action. The function of the tides consists in raising the water of the ocean sufficiently high to enable the waves to attack the cliffs, in assisting in the grinding up of the reduced rock fragments by their perpetual oscillating motion until sufficiently reduced in size, and then in transporting them to the bed of the sea, the latter operation being effected either in solution, suspension, or rolling along the bottom.

It is shown that all material eroded from the cliffs is ultimately carried seaward, and that the sea yields nothing to the land. The only agents capable of transporting material of greater specific gravity than the water are the waves, and their action, until they break on the shore, is merely one of undulation; and therefore it is on by gales, is continuous, regular, and constant in direction. It is shown by a number of examples that the travel of shingle is not coincident either with the prevailing or predominant winds, but on a tidal coast the predominant drift is invariably in the same direction as that of the flood tide. The action of the tides in heaping up and drifting material is due to wave action. The rise and fall of the tide on the coast does not consist of a mere vertical rise and fall of the water, but of a continual oscillation. The crest of the tidal wave in the open sea, being in advance of that near the shore, results in an oblique lateral movement along the beach, and the advance of the water being checked by the shallow bed with which it comes in contact, is reflected back, resulting in a series of small oscillations or waves which break when they reach the low-water line. These oscillations are ever present on the margin of the shore, even when the sea is calmest, and are never absent except when absorbed by larger waves due to gales. These tidal wavelets vary in height from 6 inches to 2 feet, and break on the shore at the rate of from ten to twenty a minute according to the rise of the tide and the slope of the beach. These wavelets, aided by the flood current, lift up and carry forward any coarse sand, loose stones, or other material with which they come in contact, and leave some portion of it stranded at the highest point to which the tide of the day reaches. The wavelets, besides lifting and transporting the shingle, brush upward the whole of the face of the bank, and gradually raise it above the line of high-water. It is shown that, though these waves are small, they by their weight and velocity develop sufficient force to move a large quantity of pebbles. A wave having a height of only a foot from trough to crest, giving a head of 6 inches, and containing a volume of water equal to a weight of ·142 ton has sufficient kinetic energy to raise 165 lbs. of pebbles a foot high. Allowing the weight of pebbles in water to be 100 lbs. to the cubic foot, each wave, if the whole of its energy be applied to the movement of the material, is capable of raising 660 pebbles 2 inches in diameter a foot; or, with fifteen waves to the minute, 9,900 pebbles a minute and 2,376,000 in a single tide, or a total weight of stone of 266·4 tons a foot high. This, however, is beyond the work actually done, as a portion of the energy of the wave is absorbed in friction. The above rough approximation of the power of the wavelets is sufficient to show the enormous power that is developed by tidal action day by day on the coast, and the capability of the wavelets due to the tides for building up shingle banks and drifting the pebbles along the beach.

II.—LEADHILLITE IN ANCIENT LEAD SLAGS FROM THE MENDIP HILLS.[1] By L. J. SPENCER, M.A., F.G.S., British Museum (Natural History).

LEAD ores have been worked in the Mendip Hills (East Somerset) ever since the time of the Romans; but during the present century operations have been chiefly confined to the reworking of the old waste heaps of slags and slimes. From these heaps upwards of 9,000 tons of lead was extracted during the ten years ending 1880. The material now being worked at Priddy has the appearance of a brown earth: it contains fragments of charcoal and limestone, and about 6 per cent. of lead as carbonate. Embedded here and there in this material are blocks consisting of devitrified slag, partially fused galena, and fragments of charcoal; and in the cavities numerous small crystals of cerussite ($Pb\,C\,O_3$) and anglesite ($Pb\,S\,O_4$) and, less frequently, of leadhillite.

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[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

Leadhillite has not been before observed under such conditions. In the Roman lead slags at Laurion in Greece, which have been in contact with sea-water, Lacroix has noted the following secondary minerals: matlockite, penfieldite, laurionite, fiedlerite, phosgenite, cerussite, hydrocerussite, and anglesite.

The colourless crystals of Mendip leadhillite have, perpendicular to the perfect basal cleavage, an acute negative bisectrix with an optic axial angle in air of $2E=72\frac{3}{4}°$; at a temperature of 97° C., $2E=70\frac{1}{2}°$. The frequent twinning and the goniometric measurements (which are, however, not very good) are not inconsistent with the orthorhombic symmetry insisted upon by Miller. The basal planes of complicated twin crystals always give a single sharp reflected image, which is not the case with twin crystals of ordinary monosymmetric leadhillite. A few crystals are optically uniaxial.

There therefore seem to be three kinds of leadhillite, all of which are identical in outward appearance: (*a*) Monosymmetric, with the

Garey, on the east side of the railway line, half a mile north from St. John's, and the same distance south from Poortown station.

The bones were nearly all in juxtaposition and, excepting the ribs and pelvic bones and one shoulder-blade, in a very fair state of preservation. The antlers were nearly complete; the beams, however, are represented by fragments, the skull also is fragmentary.

The left antler is the larger; it measures across the palm 15 inches, allowing for a piece of the front edge which has decayed away; the right measures 13 inches. With the tines, most of which dropped off on lifting from the marl, they are respectively 56½ inches and 53 inches long, and the beam would have been about 10 inches more. They show six points, besides the brow-tines, which had fallen off, the portion of the beam to which they were attached having decayed away.

The palm of the left antler lay over the lumbar vertebræ, and the right over the fore-quarters. The upper jaw teeth were preserved on both sides, and those of the left lower jaw were embedded in the ramus. A fragment of the right symphysis was also present, and there were various fragments of a skull which had been broken up before the discovery.

One of the ribs had been perforated, probably by the point of an antler of another elk in one of their usual fights. It was fractured as well as perforated, and had been healed. This injury, therefore, was not connected with the death of the animal, which took place in its full prime, as shown by the perfection of the teeth and the dimensions of the antlers.

Professor Boyd Dawkins examined the bones in December and made the measurements of the skeleton found at Close-y-Garey.

Excavation No. 1 in disturbed soil yielded fragments of upper jaw (teeth worn) of *Cervus giganteus.*

The skeleton lay in white marl at a depth of about 9 feet from the present surface, on its right side, the legs drawn up to the body, the head towards the margin of the ancient pool, now a morass, which lies in a hollow in the glacial drifts.

From the position of the bones the animal appeared to have died where it was found, not to have been washed down by floods. About sixty years ago the bog had been worked for marl, and the present well-defined banks mark out a rectangular hollow some 50 yards square and about 3 feet below the surrounding surface.

Across one corner of this a trench was dug to carry off the water, and the operations of the Committee were confined to a triangular area on the west side of the trench, measuring about 15 yards east and west, by about 30 yards north and south. They excavated all over this space to a depth of over 9 feet. The first four excavations, being through ground which had previously been disturbed, yielded no definite results, but at one point a few bones were met with, among which were fragments of maxilla, the sixth cervical vertebra, the second lumbar vertebra, and a fragment of a rib. In association with these were remains of horse represented by a radius and lower jaws of two individuals. Though the ground had been disturbed the horse bones probably belonged to the same age as the Great Deer. A fragment of a metatarsal, met with in digging the trench, had an artificial perforation.

The result of all the excavations, allowing for the disturbed state of the ground, showed the following beds:—

		Ft.	in.
A.	Disturbed soil and peat, an average of about	3	0
B.	In one place a blue clay or silt was observed resting on the white marl.		
C.	White marl containing the remains of the Gigantic Deer	6	6
D.	Blue marl[1]...	1	0
E.	Red sand with gravel	0	3
F.	Brown clay	0	3
G.	Sand and gravel } ? Glacial drift {	0	3
H.	Clay ... ... } ? Glacial drift {	4	0

As stated above, the whole surface had been lowered about 3 feet in digging for marl; the peat had for the most part been removed, and a great deal of the marl also; indeed, we were fortunate in finding this one spot in which the marl itself had not been disturbed.

The finding of detached bones shows that other individuals had perished here, and is consistent with what we were told, that a specimen had been seen when digging for marl, and that the antlers of another had been taken out. We were told also that two skulls without antlers had been seen on the other side of our trench.

Samples of the marl and other beds were forwarded to Mr. James Bennie, of Edinburgh, who again most kindly undertook the laborious task of washing and sifting the material. The organic remains thus

In our last report we were able to announce the discovery in a previous excavation near Ballough of the Arctic crustacean *Lepidurus glacialis*, and accompanied by the Arctic willow *Salix herbacea* in a bed of silt occurring above *Chara*-marl, like that of the present section. In that locality, however, we did not succeed in finding elk-remains in the marl, probably on account of the limited character of our excavation, as we have every reason to believe that the skeleton now in Edinburgh Museum was obtained from that bed. In the present instance, though we have found the elk, it will be noticed that the section contains no trace of the Arctic fauna. This is greatly to be regretted, since—as was pointed out by Mr. C. Reid in our last report—the relation of this fauna to the bed containing the elk is a point of great theoretical importance. It is also important that the presence of the horse in the wild fauna of the Isle of Man should be placed beyond doubt by working in undisturbed ground. The same group of animals may be expected as that which occurs in the prehistoric strata of Ireland and England. Under these circumstances we propose to apply for a further grant to carry on explorations which will probably definitely settle these interesting questions.

The balance of the grant, renewed last year, was expended in the preliminary work of draining; further funds, which enabled the Committee to continue the work and to exhume the specimen which has now been set up in Castle Rushen, Isle of Man, were provided by the local Society, which also contributed the amount required for mounting the skeleton.

The best thanks of the Committee are due to Messrs. C. Reid, J. Bennie, and R. Okell for the valuable assistance they have rendered in the investigation.

IV.—SUPPLEMENTARY LIST OF BRITISH MINERALS.[1] By L. J. SPENCER, M.A., F.G.S., British Museum (Natural History).

DURING the forty years which have elapsed since the publication of Greg and Lettsom's "Manual of the Mineralogy of Great Britain and Ireland," a considerable number of species, variety and other names have been added to the list of minerals occurring in the British Isles. In 1858 Greg and Lettsom recognized 241 British species, but of these only 209 are given as numbered species by Dana in the sixth edition (1892) of his "System of Mineralogy." To this list may now be added 84 more, bringing the total number of British species up to 293, as compared with the total of 824 known mineral species recognized by Dana in 1892. Owing to the difficulty in some cases of defining a mineral species, to the uncertainty of some of the determinations, and to the fact that a systematic search through the whole of the literature has not yet been made, these numbers can only be considered approximate.

Some of the most notable additions are of minerals which have been detected by the microscopical examination of rock-sections, e.g., nephelite, nosean, and various felspars, pyroxenes, and amphiboles.

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[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

In the following list are added 113 other names which have been applied to British minerals; the species are distinguished by italics. The first observer and date have been added (in parenthesis) wherever possible; in other cases the earliest reference found is given.

Abriachanite (Heddle, 1879).
Achroite (Collins, 1876).
Ægirite (Teall, 1888).
Aikinite (Museum Pract. Geol.).
Albertite (Morrison, 1884).
Alunogen (Smithe, 1882).
Amazon stone (Heddle, 1877).
Amblystegite (Judd, 1885).
Andesine (Heddle, 1877).
Andrewsite (Maskelyne, 1871).
Anorthite (Haughton, 1856).
Antigorite (Heddle, 1878).
Antimony ? (Garby, 1848).
Atacamite (Church, 1865).
Balvraidite (Heddle, 1880).
Baricalcite (Breithaupt, 1841).
Barytocelestite (Collie, 1878).
Bastite.
Bathvillite (Williams, 1863).
Bauxite (Sutherland, 1870).
Bayldonite (Church, 1865).
Beekite.
Beraunite (Greg, 1860).
Bhreckite (Heddle, 1879).
Botallackite (Church, 1865).
Bowlingite (Hannay, 1877).
Braunite ? (Collins, 1871).
Bruiachite (Macadam, 1886).
Bytownite (Teall, 1884).
Cantonite (Davies, 1877).
Cathkinite (Glen & Young, 1882).
Celadonite (Heddle, 1879).
Centrallassite (How, 1878).
Chalcosiderite (Maskelyne, 1875).
Chenevixite (Adam, 1866).
Chloritoid (Heddle, 1879).
Chloropal (Church, 1866).
Chlorophyllite (Heddle, 1882).
Chrome-diopside (Teall, 1888).
Chrysoberyl (Haughton, 1856).
Chrysotile.
Churchite (Church, 1865).
Cleavelandite (Heddle, 1877).
Clinochlore (British Museum).
Cloustonite (Heddle, 1880).
Coccolite (Heddle, 1877).
Collyrite (Gladstone, 1862).
Cotterite (Harkness, 1878).
Craigtonite (Heddle, 1882).
Crocidolite (Heddle, 1879).
Cryptolite (Church, 1872).
Danalite (Miers & Prior, 1892).
Daphnite (Tschermak, 1891).
Delessite (Heddle, 1879).
Demidoffite (Greg, 1860).
Descloizite (Frenzel, 1875).
Devilline (Pisani, 1864).
Dolianite (Des Cloizeaux, 1862).
Dudgeonite (Heddle, 1889).
Dufrenite (Kinch & Butler, 1886).
Duporthite (Collins, 1877).
Edenite (Heddle, 1878).
Electrum (Forbes, 1867).
Ellonite (Heddle, 1882).
Enstatite.
Enysite (Collins, 1876).
Eosite (Schrauf, 1871).
Eulytite (Collins, 1881).
Evansite (Woodward, 1884).
Ferrite (Heddle, 1882).
Fibrolite (Heddle, 1882).
Fichtelite (Macadam, 1889).
Freieslebenite ? (Museum Pract. Geol.).
Funkite (Heddle, 1882).
Genthite (Heddle, 1878).
Gersdorffite (Forbes, 1868).
Gigantolite (Heddle, 1882).
Glaucophane (Blake, 1888).
Gramenite (Collins, 1877).
Grastite (Heddle, 1878).
Grossular (Heddle, 1878).
Grünlingite (Muthmann & Schröder, '97).
Halloysite (Heddle, 1882).
Haughtonite (Heddle, 1879).
Hausmannite (Goodchild, 1875).
Henwoodite (Collins, 1876).
Hibbertite (Heddle, 1878).
Hisingerite (Church, 1870).
Hovite (Gladstone, 1862).
Hullite (Hardman, 1878).
Hydrated labradorite (Heddle, 1880).
Hydrocerussite (Heddle, 1889).
Hydrophilite (Spiller, 1876).
Hydroplumbite (Heddle, 1889).
Hydrozincite (Goodchild, 1883).
Iddingsite ? (Arnold-Bemrose, 1894).
Igelströmite (Heddle, 1878).
Inverarite (Heddle, 1883).
Jarrowite (Lebour, 1887).
Johannite ? (Garby, 1848).
Langite (Maskelyne, 1864).
Latrobite (Heddle, 1877).
Lepidomelane (Haughton, 1859).
Lettsomite (British Museum).
Leuchtenbergite (Glen & Young, 1876).
Leucoxene (Geikie, 1879).

Limnite (Church, 1865).
Linnæite (Terrill & Des Cloizeaux, 1880).
Liskeardite (Maskelyne, 1878).
Loganite (Harkness, 1866).
Löllingite (Collins, 1871).
Ludlamite (Field, 1877).
Lussatite (Mallard, 1890).
Lyellite (Maskelyne, 1864).
Marmolite (Heddle, 1878).
Martite (Heddle, 1882).
Massicot ? (Collins, 1871).
Melanite (Teall, 1892).
Microcline.
Mirabilite (Glen & Young, 1876).
Monazite (Miers, 1885).
Montmorillonite (Collins, 1878).
Mottramite (Roscoe, 1876).
Mountain silk, etc. (Heddle, 1879).
Necronite (Heddle, 1877).
Neotype (Breithaupt, 1841).
Nephelite (Allport, 1871).
Nephrite (Heddle, 1878).
Nosean (Allport, 1874).
Okenite (Glen & Young, 1876).
Oligoclase (Haughton, 1862).
Omphacite (Teall, 1891).
Orangite (Heddle, 1883).
Ottrelite (Hutchings, 1889).
Pargasite (Heddle, 1878).
Penninite (Heddle, 1878).
Penwithite (Collins, 1878).
Perthite (Heddle, 1883).
Phlogopite ? (Heddle, 1878).
Pickeringite (British Museum).
Picotite (Bonney, 1877).
Picrolite (Heddle, 1878).
Piedmontite (Dana, 1892).
Pihlite (Heddle, 1879).
Pilolite (Heddle, 1879).
Plumboaragonite (Collie, 1889).
Plumbogummite (Dana, 1850).
Plumbonacrite (Heddle, 1889).
Polybasite (Joy, 1860).
Polytelite (Forbes, 1867).
Prasilite (Thomson, 1840).
Protolithionite (Sandberger, 1885).
Proustite (British Museum).
Pseudo-hypersthene, etc. (Heddle, 1878).
Pseudophite (Heddle, 1879).
Pyroaurite (Heddle, 1878).
Pyrophyllite (Foster, 1876).
Pyrosclerite (Heddle, 1879).
Reichite (Breithaupt, 1865).
Restormelite (Church, 1870).
Rhabdophane (Lettsom, 1878).
Riebeckite (Harker, 1888).
Rock silk, etc. (Heddle, 1879).
Rubislite (Heddle, 1879).
Sanidine.
Scapolite (Ormerod, 1869).
Schraufite ? (Thomson, 1887).
Schrötterite (Dana, 1868).
Senarmontite (Davies, 1867).
Sericite.
Spangolite (Miers, 1893).
Spessartite (Heddle, 1878).
Stephanite (Davies, 1866).
Tallingite (Church, 1865).
Tavistockite (Church, 1865).
Thorite (Heddle, 1883).
Tobermorite (Heddle, 1880).
Totaigite (Heddle, 1878).
Tridymite (Lasaulx, 1876).
Turgite (Heddle, 1882).
Tyreeite (Heddle, 1881).
Uigite (Heddle, 1856).
Uralite.
Valentinite (Hall, 1868).
Vauquelinite (Davies, 1877).
Vermiculite (Parke, 1877).
Voltzite (Dana, 1868).
Walkerite (Heddle, 1880).
Waringtonite (Maskelyne, 1864).
Wicklowite (D'Achiardi, 1883).
Willemite (Glen & Young, 1876).
Wittichenite ? (Collins, 1871).
Woodwardite (Church, 1866).
Xantholite (Heddle, 1879).
Xanthosiderite (Haughton, 1866).
Xonotlite (Heddle, 1882).
Zeunerite (Weisbach, 1872).

V.—ON ARBORESCENT CARBONIFEROUS LIMESTONE FROM NEAR BRISTOL.[1] By HORACE B. WOODWARD, F.R.S.

A SPECIMEN of Carboniferous Limestone showing arborescent markings was obtained by Mr. Spencer G. Perceval from Brentry Hill, near Henbury, Bristol, and was presented by him in 1897 to the Museum of Practical Geology. The rock is about six inches thick, and the lower half is a current-bedded oolitic limestone. The upper half comprises banded calcareous mud with a few layers of oolitic grains, and the material in this portion of the rock has been disturbed, the layers having been bent; while the hollows

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

between the curves are partially eroded and filled with irregular detrital material containing oolitic grains.

The surface of the block presents an irregular concretionary structure, resembling that seen on many varieties of Cotham Marble; but it is not so pronounced as in some of the mammillated surfaces seen in that rock.

The appearances are probably due to mechanical disarrangement of the upper layers produced prior to and during the consolidation of the rock, and they suggest a pause in the deposition of sediment.

It is noteworthy that the darker bands which produce the arborescent markings stand out slightly in relief on the weathered face of the block of Carboniferous Limestone. This is also the case with an example of Cotham Marble which I lately obtained on the South Wales Direct Railway at Stoke Gifford.

A small specimen of Carboniferous Limestone from Backwell, near Nailsea, given to me by Mr. W. H. Wickes, shows indications of arborescent markings. [Further references to the subject are given in the GEOL. MAG., Dec. III, Vol. IX, 1892, p. 110, and in "The Jurassic Rocks of Britain," Mem. Geol. Surv., vol. v, p. 230; see also B. Thompson, Quart. Journ. Geol. Soc., vol. L (1894), p. 393.]

VI.—THE BUILDING OF CLIFTON ROCKS. By E. WETHERED, F.G.S.[1]

IN this paper the author confines his remarks chiefly to the microscopic life which he has discovered in the Carboniferous Limestone rocks at Clifton. He contends that microscopic calcareous organisms have been the chief contributors to the vast deposits in the Carboniferous sea, now represented by the cliffs on either side of the gorge of the Avon at Clifton.

Broadly speaking, there were three stages in the formation of this limestone. These were regulated by physical conditions, and favoured the existence of certain forms of life. The fossil remains now denote the stages. They are as follows:—

	Approximate Thickness.
Stage 1. Lower Limestones (including the Lower Limestone shales, 500 feet, and Black Rock series, 470 feet)	990 feet.
Stage 2. Middle Limestone	1,620 „
Stage 3. Upper Limestone	100 „

The close of the Old-Red Sandstone period is marked by variegated sandstones and shales. These beds pass into limestones and shales, and these again are followed by massive limestones locally known as the Black Rock; the whole representing the Lower Limestones, or Stage 1.

During this stage encrinites were so numerous in the waters that the ossicles of these creatures are a distinguishing feature of the limestones. Vast numbers of ostracoda at times lived, and some beds of the limestone are chiefly accumulations of the remains of these small crustaceans. Monticulipora corals and polyzoa were numerous in the waters, and also mollusca.

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[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

Another interesting feature, not before noticed in the Lower Limestones, is the mass of incrusting organisms. These organisms formed a crust around the fragmental remains of other bodies which collected on the sea-floor, and to such an extent did this process go on that the incrusting organisms contribute considerably to the building up of some beds of limestone. Whether these crusts are to be attributed to animal or vegetable growth is a matter of doubt.

The crinoidal life reached a climax during the time that the Black Rock Limestone was in process of formation. Indeed, this rock is, in the main, a vast accumulation of the ossicles of these "stone-lilies." associated with shells of mollusca, fish remains, etc.

The Black Rock series terminate in dolomitized limestone, and on this rest the 'Gully Oolites.'

The Lower Limestones terminate at these oolites, in which occur, though sparingly, foraminifera and the minute spherical object *Calcisphæra.* This latter body averages about ·012 of an inch in diameter, but, small as it is, the calcareous sphere has been an important contributor to the building of the rocks.

As *Calcisphæra* is confined to the Carboniferous Limestone, and is so numerous that it is seldom a thin section of the rock is obtained without finding it, the organism is useful in determining the strata when doubtful. So far, the author has not found *Calcisphæra* in the Lower Limestones, and the same remark applies to foraminifera.

Above the horizon of the Gully Oolite the lower beds of the Middle Limestone are characterized by the occurrence of the curious organism *Mitcheldeania*, but it is not confined to this horizon.

Next follow limestones and calcareous shales full of the remains of little understood forms of microscopic life, which must have existed in great profusion.

As before remarked, the Middle Limestones are characterized by foraminifera and *Calcisphæra.* At first these occur sparingly, but later on the rock is little more than a Carboniferous foraminiferal ooze. Remains of corals occur and other well-known fossils, but the bulk of the 1,600 feet of limestone included in the Middle Series is in the main a vast calcareous deposit of the remains of microscopic life which lived in the Carboniferous waters.

Owing to the Upper Limestones being so built over, the author is at present not in a position to describe the microscopic life which the strata probably contain associated with larger organisms.

VII.—ON THE PROBABLE SOURCE OF THE UPPER FELSITIC LAVA OF SNOWDON.[1] By J. R. DAKYNS, M.A.

BETWEEN Glaslyn and Bwlch Goch, as the lowest part of the ridge between Crib Goch and the top of Crib y Ddysgl is called, a mass of felstone rises like a wall through the beds of the calcareous ashy series. The trend of the dyke is E.N.E. The best section is along the N.W. face, where the felstone is clearly seen standing as a wall against the truncated edges of the calcareous ashy beds. The felstone shows *lines of flow parallel to its side*, and in some places is rudely columnar, *the axes of the prisms being perpendicular to the side of the dyke.* It is owing to this arrangement of the columns, and of the lines of flow, that I consider the rock to be a dyke. I call it a dyke because of the straightness of its sides; but it is rather a boss than a dyke, as, while it is two hundred yards wide, it is only about three or four hundred yards long. The rock is not like any of the lower Snowdonian felsites occurring in the immediate neighbourhood, but it is decidedly like the upper felstone, which forms outliers on Crib Goch and Crib y Ddysgl. It seems to me that we have here the source of the upper felsitic lava of the Snowdon district. The boss is a plug of rock consolidated in and filling up the orifice through which the upper lava flowed to the surface.

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[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

VIII.—ON WORKED FLINTS FROM GLACIAL DEPOSITS OF CHESHIRE AND THE ISLE OF MAN.[1]

By J. LOMAS, A.R.C.S., F.G.S., Pres. Liverpool Geol. Soc.

FLINTS are not common in the glacial deposits of N.W. England. In one or two places in the Wirral, however, and in the Isle of Man, they are fairly plentiful. Sometimes they occur in the Boulder-clay, but more frequently in Glacial Sands and Gravels. Some of the flints collected in these localities show undoubted signs of human workmanship.

Prenton, Birkenhead.—The flints exhibited were collected from a recent excavation near Mount House. Soft Bunter is seen on the south and west faces overlain by glacial sands. Between the two lies a bed of gravel containing small Lake District and Scotch erratics up to six inches in diameter, along with broken Triassic rocks, clay galls, and marine shells. In this gravel most of the flints have been found. Others occur in the overlying sand, which also contains erratics and shell fragments. Similar sand occurs at many places in the immediate neighbourhood, and is usually overlain by Boulder-clay.

Spital Sandpit. — False-bedded clean sand is seen, containing gravel and rolled clay galls, overlain by tough Boulder-clay. The flints occur both in the gravel and Boulder-clay.

Capenhurst.—Flints collected from gravel bands and clay in old sandpit opposite church.

Mollington, near Chester.—The large sandpit, near high road, contains very little gravel, and the flints mostly occur in the Boulder-clay which caps the section.

Cliffs north of Ramsey, Isle of Man.—Glacial deposits in north of island well exposed in the fine cliffs which extend from Ramsey almost to the Point of Ayre. Near Ramsey, sands and gravels predominate, and these get successively more and more clayey towards the north.

In collecting the flints I took great care to separate those found in the talus slopes from those actually in the clays and gravels. The *flints are* exhibited and speak for themselves.

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[1] *Read before Sect.* C (Geology), British Association, Bristol Meeting, Sept. 1898.

REVIEWS.

I.—FOSSIL MEDUSÆ. By CHARLES DOOLITTLE WALCOTT, F.G.S. Monographs of the United States Geological Survey, Vol. XXX. 4to; pp. 201, pls. 48, figures in text 26. (Washington, 1898.)

THE main interest and importance of this Monograph on Fossil Medusæ depend on the descriptions given of some peculiar bodies, regarded by Professor Walcott as casts of Discomedusæ, which occur in considerable numbers in shales, of Middle Cambrian age, in the Coosa Valley, Alabama. These bodies are found in intimate association with siliceous nodules, sometimes apparently constituting the entire nodule, at others in solid projecting relief on the outer surface, and also entirely enclosed and surrounded by the mineral constituents of the nodule.

The semi-cherty nodules, or star-cobbles as they have been termed, in allusion to their radiately lobed forms, which suggest a rude resemblance to starfishes or sea-urchins, occur as narrow bands in the finely laminated shales; and they weather out on the surface and in the drainage channels of the district in such abundance that 9.000 specimens were collected for study by the United States Geological Survey, but only about one-fourth of these show the presumed medusæ, and many seem to have been formed independently of the presence of any organisms. Other nodules, however, contain fragments of the characteristic fossils occurring in the shales, such as brachiopods, trilobites, and in a few instances casts of hexactinellid sponge spicules; the trilobite tests are now replaced by crystals of quartz. Further, the nodules are traversed in all directions by fine annelid borings, which penetrate the matrix and medusæ casts equally.

The medusoid nodules have been carefully examined microscopically and chemically. Professor Iddings reports that they consist of a mixture of granular quartz in allotriomorphic grains, occasional flakes of muscovite mica, and a small amount of calcite, gas pores, and colouring matter, probably carbonaceous. Dr. Hayes states that thin sections under low microscopic powers show a close resemblance to ordinary cherts. They have a finely mottled-grey appearance in polarized light, the extinction being similar to that of cryptocrystalline or chalcedonic silica. The chief differences between the nodules and ordinary chert, when seen under a magnification of 100 diameters, are the presence in the former of mica flakes, in more or less abundance, and the absence of rhombohedral cavities, usually found in the chert concretions formed in a calcareous matrix. But under a power of 400 diameters Dr. Hayes found a marked distinction between the nodules and chert; the former seemed to be almost wholly composed of two kinds of extremely fine grains with sharply defined outlines. One kind is original detrital quartz, the other a hydrous silicate of *alumina* or clay. If amorphous silica be present at all, it is inconsiderable in amount. No concentric structure is to be seen in the nodules, but some show lamination marked by parallel mica scales, as if the nodule were produced by a silicification of a portion of the stratified mud or shale. A chemical analysis of a portion of a nodule within the body of a medusa showed 83·33 per cent. of silica, nearly 4 per cent. of calcite, and 4 per cent. of alumina; whilst the shale in which the nodules are imbedded consists of 55 per cent. of silica, 21 per cent. alumina, and under 2 per cent. calcite.

The bodies described as silicified medusæ are very varied in form; so much is this the case that it is difficult to find any two alike. Those placed under the genus *Brooksella* are for the most part discoidal or cake-shaped bodies from 1 to 5 cm. in diameter, with a depressed convex upper surface, consisting of a number of lobate arms or rays extending from a common rounded central area. These lobes are considered to be the umbrella of the jelly-fish; there are from six to more than twenty of them in different individuals; some are narrow, subcylindrical, and terminate obtusely, whilst others are expanded or club-shaped distally. On the under surface of these bodies there is another series of arms, proceeding, like those of the upper surface, from the central area or axis, which are regarded as the lobes of the sub-umbrella; and, further, in some specimens, between the upper and under series, there is yet another set of lobes, attached to the central axis, belonging to the inter-umbrella. This peculiar combination of lobate arms "results in a very complex structure, and instead of a simple symmetrical medusa, an irregularly lobed body results, with round appendage-like lobes projecting out in various directions from the central disk or axis." In each lobate arm of these different series a simple radial canal extended, and opened into the central axis which is believed to represent the central stomach of the organism. Judging from the figures, these radial canals are often shown as small circular openings at the distal extremity of the lobes, or, when exposed in section, as narrow infilled tubes of a different coloration in their axial line, and they are very similar in appearance to the canals of fossil sponges when infilled with silica. No trace of an oral opening has been noticed in these bodies, and in only one specimen an oral plate, formed by the union of four arms at the centre, has been recognized. Tentacles are unknown.

In a second genus, *Laotira*, there is a still more complex development of lobate arms, and in some compound forms three radiate centres appear to be present, and the lobate arms from each intercommunicate with one another.

Assuming that these peculiar bodies are fossil medusæ, the question naturally arises as to the mode in which they can have been preserved, so that not only the numerous lobate arms and appendages, but even the axial canals within them, retain their original form as solid casts in silica. The author fully recognizes that, according to present opinion, such delicate organisms can only have been preserved as fossils by faint impressions in fine calcareous mud, sandstone, or shale; but he is very firmly convinced that these silicified bodies are the casts of medusæ, and explains their present condition by supposing that, like the recent *Polyclonia frondosa* of the West Indian seas, the organism lived on a muddy bottom, with the dorsal surface of the umbrella—disk downwards and the tentacles turned upwards; and thus, under favourable conditions of burial by a rapid deposition of sediment, the watery contents of the medusa would be sufficiently retained so as to avoid a collapse, whilst the sediment penetrated into the interior and had time to harden. In the case of forms showing the canals the author considers "that these and the other internal cavities of the organism were filled at once, to a greater or less extent, by the soft siliceous ooze or mud. As the animal matter decomposed, the ooze gradually took its place, and then began the silicification of the sediment that resulted in the formation of the cast of the medusa, and of the nodules by the extension of the silicification into the surrounding sediment."

These "silicified medusæ" are so fully described and illustrated in the monograph that palæontologists will be enabled to form their own opinion upon them. Many of this sceptical race, particularly those who have picked their way on a sandy shore strewn over with the unsubstantial bodies of jelly-fishes, will probably hesitate in accepting these solid forms as medusæ. The author states that he has considered the alternative question whether these peculiar bodies may not have been siliceous sponges, but the absence of spicules in a large number of microscopic sections examined, and the fact that some of the forms occur as compressed films in the shale, led him to reject this view of their origin.

In the same family with the Middle Cambrian forms, Professor Walcott also places the *Dactyloidites asteroides*, Fitch, sp., which occurs as dark stains in the slates of Lower Cambrian age in Eastern New York. This fossil was originally described as a marine alga, but the author regards it as the body of a medusan flattened in the slate, and not the cast of the interior.

With respect to the fossil medusæ from the Lower Cambrian of Sweden, we think that the impression of *Medusites Lindströmi* figured by Dr. Nathorst in "Sveriges Geologi" and reproduced in this monograph, fully establishes the existence of medusæ on this horizon.

Following the description of the Palæozoic medusæ, the author refers to those from the Jurassic strata of Bavaria, and then notices those reported to occur in flint nodules from the Chalk of Europe. A collection of these latter from the Natural History Museum of Hamburg proved on examination to belong to sponges, as had indeed been suspected by Dr. Gottsche, and not improbably other reputed medusæ in flint will be found to have a similar origin.

The admirable series of plates which accompanies and illustrates the text of Mr. Walcott's Monograph greatly facilitates the understanding of the author's views in regard to the remarkable bodies he has so minutely and carefully described. G. J. H.

II.—The Principles of Stratigraphical Geology. By J. E. Marr, M.A., F.R.S. 8vo; pp. 304. (Cambridge: at the University Press. Price 6s.)

THE object of the present work is to give "some idea of the methods and scope of Stratigraphical Geology"; and the task of the Stratigraphical Geologist, as the author clearly states it, is "to record the events which have occurred during the existence of the earth in the order in which they have taken place." The subject is confined within tolerably strict limits, and it is treated solely in its scientific aspect: we have no digressions on the form of the ground, and no references to the economic applications of stratigraphical knowledge. The nature of stratified rocks, the means by which the order of succession is established, the method of formation of the strata, the general conditions of each period, and the correlation of the groups of strata, are the chief matters discussed; and they are introduced in orderly succession after a short account of the growth and progress of stratigraphical geology.

The Cambridge School has acquired a deserved name for cautionary teaching, and the author very fully places before his readers many considerations that should be weighed before coming to definite conclusions. In a useful chapter on "Simulation of Structures," he draws special attention to pseudo-organisms, false ripple-marks, diverse parallel structures, and crush-conglomerates or (as he prefers to call them) fault-conglomerates; and when the student comes to deal with our stratified formations, with classification and correlation, he will find more than enough of vexed questions over which to ponder.

One of the earliest of geological lessons is that all kinds of sediment are being laid down in various aqueous areas, from coarse detritus to deep-sea ooze, and that at the present day there is a gradual change in the character of the fauna which exists at various depths and at varying distances from the sea-margins. When we come to the stratified formations which constitute the bulk of the land on which we live, we learn that in those typical localities which first gave name to the formations only limited portions of the sea-bed of the period can there be represented. Such names as Wenlock Shale, Inferior Oolite, Oxford Clay, Lower Greensand, and London Clay indicate the lithological character of formations at so-called typical localities. Subsequent study has shown the presence on the same general horizon of strata of quite different lithological characters, and different local subdivisions with local names have come to be applied, such as the Denbighshire Grits, the Lincolnshire Limestone and Northampton Sands, the Spilsby Sandstone, Tealby Clay, etc. From such local phenomena the geologist may seek to push his inquiries into the wide world and study the general sequence of events, and he then requires chronological terms of broad significance.

It is now that the student has to face many and difficult problems which are fairly and as fully as possible stated by the author. While each great group of strata has a series of characteristic fossils, their distribution in time and space varies greatly in most cases. We have to bear in mind that the organic remains to be found in limestones, clays, and sands of the same age will differ in a marked degree. Nevertheless, there are to be found certain widely diffused forms—trilobites, graptolites, brachiopods, belemnites, ammonites, and others—which serve to act as indices of age. Species of some of these fossils have been found to occur in definite sequence, as definite as the sequence of strata, but irrespective of the kinds of sediment. Consequently there have been established certain 'zones' which are characterized either by one or more particular species or by assemblages of fossils. They are clearly palæontological horizons, for they are not lithological divisions of the strata. In a conformable series no one knows the precise limits of range of any one species. In useful diagrams given by the author (p. 62), he shows how each species may have a varied range in time in a formation or series of strata. No doubt each species has its definite chronological and geographical limits, although we can never know exactly what these are. The author remarks that, "strictly speaking, the term zone (a belt or girdle), when applied to distribution of fossils, should refer to the belt of strata through which a fossil or group of fossils ranges." We do not quite agree with the author in this definition. Zones of course must be identified by fossils and not by the strata; and therefore they serve to indicate periods of time rather than masses of sediment. We could hardly speak of a zone which is represented partly in Upper Greensand, partly in Red Chalk, and partly in Gault Clay as forming a belt of strata. A zone may be represented, as the author points out, in strata 8 inches thick or 5,000 feet thick; but the true belts of strata are such as he well represents in his diagram, p. 175, and we wish he had given more of these stratigraphical figures.

The author devotes a brief chapter to geological maps and sections, and points out the great advantage of drawing longitudinal sections to a true scale. In addition to the ordinary geological maps which depict the stony structure of the country, he would like to have also a set of chronological maps founded on the sequence of fossil organisms. We wonder who could construct such zonal maps. It is possible that over small areas, by aid of numerous excavations and long-continued fossil-collecting, something might be done to indicate in a rough way the palæontological divisions. We should like the author to map (irrespective of any lithological aid) the Upper Cretaceous subdivisions—the Albian, Cenomanian, Turonian, and Senonian, to use the chronological terms which are sometimes employed. We doubt, indeed, if any field-geologist would find these terms so useful on the ground in this country as Gault and Upper Greensand, Lower, Middle, and Upper Chalk.

The author very properly points out that "The establishment of a classification on palæontological lines by no means does away with the necessity for local classifications on a lithological basis." Each country is apt to frame its local classification on stratigraphical and lithological grounds, hence when local terms from other countries are introduced their true meaning is altered and confusion arises. Such has been the case with terms like Cenomanian, Portlandian, Kimeridgian, and Callovian. The term Portlandian should only be used for the period represented by the Portland Beds of Portland, the Callovian for the period represented by the Kellaways Beds of Kellaways, and so on.

The student who peruses Mr. Marr's handy book will be prepared to encounter numerous difficulties, but his path will have been smoothed by the many useful explanations and suggestions, and he will be prepared to weigh the possibilities and probabilities before coming to definite conclusions. After all, the chief difficulties which beset the student are not in the folds and overthrust faults which locally interfere with the true sequence, nor in the determination of the method of origin of the strata, nor even in the correlation of formations when the organic remains have been carefully studied and determined. The greatest difficulties are in the identification of species amid the "tangled mazes of the synonymy"; and the best chance of doing good work in stratigraphical geology is to specialize on formations and faunas, aiding local research by a study of what has been done in other parts of the world. To endeavour to do a little well must be the aim of all students, and Mr. Marr's work will surely aid the enthusiastic inquirer in dealing with the many problems which come before him.

III.—OUTLINES OF THE EARTH'S HISTORY: A POPULAR STUDY IN PHYSIOGRAPHY. By N. S. SHALER, Professor of Geology in Harvard University. 8vo; pp. iv, 417, with 10 full-page Illustrations and 23 Figures in the text. (London: W. Heinemann, 1898.)

THE object of this book, as stated in the preface, "is to provide the beginner in the study of the earth's history with a general account of those actions which can be readily understood, and which will afford him clear understandings as to the nature of the processes which have made this and other celestial spheres." The treatment of this widely embracing, one might almost say boundless, subject is brought within the compass of nine chapters, the titles of which will give a clue to their contents. The first is an introduction to the study of Nature, followed by a somewhat abstrusely historical, rather than practical, account of the ways and means of studying it. The succeeding chapters are on the Stellar Realm; the Earth; the Atmosphere; Glaciers; the Work of Underground Water; the Soil; and lastly, the Rocks and their Order. Under these heads very good descriptions are given of the most important natural phenomena, and they are principally illustrated by examples to be found in North America, which, though less likely to be familiar to students in this country, are oftentimes of a more striking and representative character than instances drawn from more limited areas. To some of the statements given exceptions might be made; for example, that the floors of the deeper seas are plentifully scattered over with volcanic cones! A novel explanation of the origin of the clayey partings or division planes in limestones is, that they arise from the action of earthquakes which result in shaking up the fine silt of the bottom of the ocean and produce a mud which is fatal to the breathing organs of the animals living on the sea-floor, and consequently the materials of these shaly layers are mostly inorganic!

Though Professor Shaler's work is, perhaps, more especially adapted for the scientific public of the United States, it nevertheless contains much that deserves the attention and consideration of geological students generally.

IV.—A STUDENT'S TEXTBOOK.

AN INTERMEDIATE TEXTBOOK OF GEOLOGY. By Professor CHARLES LAPWORTH, F.R.S. Founded on the "Introductory Textbook of Geology" by the late David Page. pp. 414, with 174 Illustrations. (London: William Blackwood & Sons, 1899.)

ENGLISH teachers of Geology are to be congratulated upon the issue of a new edition of Professor Lapworth's revision of Page's "Introductory Textbook." The book is an even greater improvement on the 12th edition than that was on its predecessors. The new issue is better illustrated; some unfortunate misprints and errors which slipped into the pages of the 1888 edition have been removed; the palæontological nomenclature is more modern; and the book is so much larger that it well deserves its new title of an "Intermediate Textbook of Geology." The work as it now stands is essentially a British student's textbook, and for students after their first year's course it seems to us quite indispensable.

The most remarkable feature in the book is that it is crowded but clear. The information is very condensed, but the main outlines are graphic. Professor Lapworth shows his unusual power of making every subject appear real with detail, while the main idea stands out with the clearness of a diagram.

The account of British geology is illustrated by a series of new and lucid maps, each showing the range of one system and the areas of early and later formations. The stratigraphical section is naturally the best, and is well up to date. Regarding it we have only one regret, Professor Lapworth's systematic self-suppression. One naturally expects to learn his opinion on disputed questions; and as a rule one has to read between the lines. For the author is careful not to encourage students to abandon orthodox beliefs too readily, and his own opinions have to be guessed from the insertion of such reserving clauses as "have been regarded," "is supposed to have been," or "it is held by some." Most geologists would probably have preferred the book to have definitely told us what Professor Lapworth himself regards, supposes, or holds in reference to the main disputed problems.

A feature in the new edition which is especially worthy of notice is the series of masterly sketches of foreign geology; they are short and up-to-date, and always bring out the most important points. It is perhaps a pity to have left in the old and probably mythical idea of the tropical condition of Greenland in Miocene times.

The palæontological summaries are illustrated by many figures, of which the new ones are of unusual clearness and softness. The legends of the old blocks might have been further revised; for instance, the fossil numbered 3 on p. 339 is certainly not even a member of the genus to which it is referred. It is possibly not an oversight that has led the author to record a common Silurian starfish as a *Protaster*, although it was made the type of a new genus and family, *Lapworthura* and Lapworthuridæ. A misconception regarding the London Clay bird *Odontopteryx* may be noticed, as it is widespread: the bird is described as "dentigerous or toothed"; the latter term is not absolutely incorrect, as it is not unusual to speak of prominences on a beak as teeth, but "dentigerous" certainly suggests that the bird had true teeth like the American Odontornithes. But the errors of this sort are comparatively trivial, and a certain number is inevitable in a book so full of information. The new textbook may be confidently recommended to teachers for the clearness of its statement of leading principles, the terseness of its summaries of facts, and its graphic sketch of British geology.

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.

I.—December 21, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair.

The President announced that Mr. F. W. Harmer, F.G.S., had most generously offered to the Society the manuscript maps of the Drift of the Eastern Counties made by the late Mr. Searles Wood, jun., and by himself. The Council, in accepting the maps, had passed a resolution specially thanking Mr. Harmer for the gift, and the Fellows were now asked to add their thanks to those of the Council.

The following communications were read:—

1. "On a Megalosauroid Jaw from Rhætic Beds near Bridgend, Glamorganshire." By E. T. Newton, Esq., F.R.S., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The specimen which forms the subject of the present communication was obtained from Mr. John David of Porthcawl, from a mason, and it has been presented to the Museum of Practical Geology. It was derived from beds low down in the Rhætic Series, which may eventually have to be included in the upper part of the Keuper. The lamellibranchs on the same slab appear to be *Pullastra arenicola* and possibly *Myophoria*. The specimen has been compared with reptilian jaws in the British Museum; it consists of a mould of the dentary bone with several teeth in place. The impression of the whole of the inner surface and of the anterior half of the outer surface is preserved. The front half of the inner surface of the jaw is like that of *Megalosaurus*, except in size. Many of the teeth are seen in various stages of projection from their sockets, and the points of two successional teeth may also be seen, and thus the mode of succession of the teeth may be clearly understood. The specimen does not admit of exact comparison with *Megalosaurus*, and it is named as a new species of *Zanclodon*—a genus in which the author is also inclined to place some forms described under the names of *Palæosaurus, Cladyodon, Avalonia,* and *Picrodon.*

2. "The Torsion-Structure of the Dolomites." By Maria M. Ogilvie, D.Sc. [Mrs. Gordon]. (Communicated by Professor W. W. Watts, M.A., Sec. G.S.)

The paper opens with a general account of the work of Richthofen, Mojsisovics, Rothpletz, Salomon, Brögger, the author, and others on the Dolomitic area of Southern Tyrol. It then gives the results of a detailed survey recently made by the author of the complicated stratigraphy of the rocks of the Gröden Pass, the Buchenstein Valley, and the massives of Sella and Sett Sass; together with the author's interpretation of these results, and her application of that interpretation to the explanation of the Dolomite region in general. The author concludes that overthrusts and faults of all types are far more common in the Dolomites than has hitherto been supposed. The arrangement of these faults is typically a torsion-phenomenon, the result of the superposition of a later upon an earlier strike. This later crust-movement was of Middle Tertiary age, and one with the movement which gave origin to the well-known Judicarian-Asta phenomena. The youngest dykes (and also the granite-masses) are of Middle Tertiary age, while the geographical position of both is the natural effect of the crust-torsion itself. This crust-torsion also fully explains the peculiar stratigraphical phenomena in the Dolomite region, such as the present isolation of the mountain-massives of Dolomitic rock.

The Gröden Pass area, first selected for description by the author, is a distorted anticlinal form running approximately N.N.E. and S.S.W., and including all the formations ranging from the *Bellerophon*-Limestone, through the Alpine Muschelkalk and Buchenstein Beds, to the top of the Wengen Series. When studied in section, the strata of the Pass are found to be arranged in a complex fold form, showing a central anticlinal with lateral wings, limited on opposite sides by faults and flexures. Strongly marked overthrusting to S.S.E in the northern wing is responded to by return overthrusts to N.N.W. in the southern wing. The strata in the middle limb of the anticlinal wings bend steeply downwards into knee-bend flexures. Through these run series of normal and reversed faults, into which has been injected a network of igneous rocks, giving rise to 'shear-and-contact' breccias, which have previously been grouped as Buchenstein tuff and agglomerates, and referred to the Triassic period.

The area of movement of the Gröden Pass system is an ellipsoid in form. Two foci occur within it, where the effects of shear and strain have culminated. The forces of compression acted not in parallel lines, but round the area, thus causing torsion of the earth-crust. Two main faults occur (with a general east-and-west trend) whose actual lines of direction intersect at a point about midway between the foci of the torsion-ellipsoid. These are the chief strike torsion-faults; many minor ones pass out easterly and westerly from the foci, forming longitudinal or strike torsion-bundles. The strike system of faults is cut by a series of diagonal or transverse curved branching faults, with a more or less north-easterly or north-westerly direction. These diagonal faults may cut each other, or may combine to form characteristic torsion-curves. The author regards the longitudinal and diagonal faults as constituting one system. Each portion on one side of the anticlinal form of the system has its reciprocal on the other side. The Spitz Kofl syncline on the north is the reciprocal of that of Sella on the south, the Langkofl on the south-west of that of Sass Songe on the north-east, and so on.

The anticlinal area of the Buchenstein Valley is next described. Here we have a torsion-system similar to that of the Gröden Pass, and made up of similar elements; but the western portion of the anticlinal is much compressed and displaced. Opposing areas of depression are also found here, that of Sella and Sett Sass on the north being reciprocated by that of the Marmolata on the south, and so on. The porphyrite-sills have here been mainly injected into the knee-bends of the northern wing of the anticlinal form, but igneous injections and contact-phenomena are also met with in some of the transverse faults.

A full description is given of the sequence and stratigraphy in the Sella massive—once regarded by some authorities as a Triassic coral-reef. This is an ellipsoidal synclinal area with N.N.E. and S.S.W. axes twisted to north-east and south-west. Peripheral overthrusts have taken place outward from the massive, in such a way as to buckle up the rocks like a broad-topped fan-structure, and these overthrusts are traced by the author completely round the massive. A central infold of Jurassic strata occurs on the plateau, where the Upper Trias has been overthrust inwards on three sides of the infold. The author next passes in review the results obtained in the areas of Sett Sass, etc., and shows how they all present corresponding tectonic phenomena.

The district thus studied in detail by the author forms a typical unit in the structural features of the Dolomite region. It is cut off to the eastward by the limiting fault (north-and-south) of Sasso de Stria, and to the westward by the parallel fault of Sella Joch. These are definite confines, which limit a four-sided area, influenced by the Gröden Pass torsion-system on the north and the Buchenstein Valley system on the south. The limits of this four-sided figure include a compound area of depression (formed by the Sella and Sett Sass synclinals) traversed by the diagonal Campolungo buckle.

"The area displays in a marked degree the phenomena of interference cross-faults cutting a series of peripheral overthrusts round the synclines, and parallel flexure-faults between the anticlinal buckles and the synclinal axes."

In conclusion, the author applies her results to the interpretation of the complexities of the Judicarian-Asta region of the Dolomites in general, and also to the explanation of the characteristic structural forms of the Alpine system as a whole.

II.—January 4, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Captain A. W. Stiffe, in exhibiting a fossil *Cardium* (?) from the beach at the foot of the cliffs of Ormara (Makran Coast), made the following remarks:—"The specimen on the table has been kindly lent to me by Mr. Ffinch, Director of the Government Indo-European Telegraphs. The peninsula of Ormara, whence the shell comes, is composed of a mass of flat-topped hills about 10 miles in length; it is about 1,200 feet high at its western end, sloping down to about 400 feet at its eastern end—flat on the top, and ending on all sides in cliffs. The rocks are chiefly clay, with a thin conformable capping of shelly breccia 20 to 60 feet thick. The fossils in the clay are difficult to find, and probably are generally enclosed in nodules of the clay somewhat altered, as in this specimen. The fossil now exhibited was picked up on the sandy beach near the foot of the cliffs, which are naturally undergoing rapid denudation. In a paper read by me before this Society in 1874, the formation was considered to be of Miocene age by Mr. Etheridge. I should be glad to learn whether this fossil supports that view of the age. Nearly all the coast in question for many hundreds of miles is of similar formation; the strata are as a rule slightly inclined only and of fantastic outline."

The following communications were read:—

1. "Geology of the Ashbourne and Buxton Branch of the London and North-Western Railway.—Ashbourne to Crake Low." By H. Arnold-Bemrose, Esq., M.A., F.G.S.

The southern part of the new railway from Ashbourne, through Tissington and Crake Low, to Buxton exhibits several sections in Trias, Boulder-clay, Mountain Limestone, and Yoredale Beds. Interstratified with the latter is a thick bed of volcanic ash, with thinner intercalations of tuff. Within a mile of Tissington ash is exhibited four times in the cuttings, and according to the view of the author it is the same bed repeated by basins and domes, one of the latter of which is faulted. While the rocks succeeding the ash in some places are limestones, cherts, and shales of Yoredale type, in one section they resemble more closely the upper beds of the Mountain Limestone. The limestones are often dolomitized. The ash-bed is 144 feet thick where fully exposed; it is stratified, the beds varying in texture, and the lapilli in them range from microscopic dimensions to 1 inch in diameter. The lapilli are glassy or palagonitic; but felspar-microlites are rare, and the rock of which they are made has no counterpart among the lavas of the county. The ejected blocks in the ash vary from several inches up to 1 foot in diameter, and are similar to the blocks in the vent at Kniveton. The small lapilli scattered through the limestones are generally converted into calcite or dolomite with oxide of iron. The paper was illustrated by microscopic slides, and horizontal and vertical sections of the cuttings and quarries described; also by hand-specimens, photographs, and lantern-slides.

2. "The Oceanic Deposits of Trinidad." By Prof. J. B. Harrison, M.A., F.G.S., and A. J. Jukes-Browne, Esq., B.A., F.G.S.

"The object of this communication is to present some observations on the succession and geological relations of the beds which have long been known in Trinidad as the Naparima Marls. This name was given by Messrs. Wall & Sawkins in 1860, on account of their occupying a large part of the Naparima district east and south-east of San Fernando. The beds so named formed one of the five series which were described by these authors under the head of the Newer Parian Group." In his historical introduction Mr. Jukes-Browne deals with the writings of Mr. Guppy and Professor Harrison, and shows that three definite issues are thus raised:—(1) Are the Nariva Beds above or below the Naparima Marls? (2) Do the *Globigerina*-marls occur in the Naparima district, and, if so, are they connected with the Radiolarian marls or are they part of a separate formation? (3) What is the relation between the San Fernando Beds and the other groups? Mr. Guppy and Professor Harrison agree in answering the first part of the second question in the affirmative, and in stating that the two marls are closely connected together.

In the second part of the paper Professor Harrison tabulates the following succession in the Naparima district:—

3. Radiolarian beds resembling those of Barbados.	Oceanic Series.
2. Grey *Globigerina*-marls, the same as those of the coast-section.	
1. Red and blue clays.	Nariva Beds.

Although junctions of the Nariva Beds and the Oceanic Series are not seen, at Ste. Madeleine Usine the clays of the former series occur 30 feet lower than the *Globigerina*-marls, and there appears to be no transition between the two series. On the other hand, the transition between (2) and (3) appears to be complete. 'A comparison with the corresponding beds at Barbados now becomes possible, and this shows that the *Globigerina*-marls occupy the place of the basal chalks of Barbados, but are much thicker, while the radiolarian rocks are thinner, and the interbedded volcanic ashes so frequent in Barbados are wanting in Trinidad. Chemical and microscopic analyses of the *Globigerina* and radiolarian beds are given, and, compared with similar analyses of the Barbadian deposits, they show that more quartz and argillaceous matter occur in Trinidad. The radiolarian marls contain iridescent scales due to fragments of the frustules of the diatom *Ethmodiscus*, which is "quite characteristic of some of the deepest tropical red clays and radiolarian oozes far from land." The 'argiline' beds appear to be formed from the alteration of the lower *Globigerina*-marls. The following correlation is proposed:—

BARBADOS.		TRINIDAD.	
Coral Rocks Bissex Beds		Moruga Series	*Pleistocene and Pliocene.*
Oceanic Beds		Naparima Marls	*Miocene.*
Scotland Beds	Upper	San Fernando Beds	*Oligocene and Pliocene.*
	Lower	Nariva Series	

The Oligocene and Eocene beds are of shallow-water origin, and seem to be unconformably covered by the Naparima Marls.

CORRESPONDENCE.

CRYSTALS FROM DECOMPOSED TRAP.

SIR,—Early in the year, in examining some refuse-heaps near Dreghorn, Ayrshire, I found a few crystals which had been weathered out from a decomposed trap. The altered rock is white, and on exposure has fallen into dust, leaving the crystals isolated and perfectly sharp. In some places the rock is particularly white, and the crystals themselves have been reduced to powder. Much of the trap is a hard solid rock, with large conspicuous aggregates of enclosed crystals; every variety from the solid rock to the altered 'white horse' (a local name of white trap) can be obtained. I am informed by Mr. L. J. Spencer, of the British Museum (Natural History), that the isolated crystals are really pseudomorphs of serpentine after augite.

J. SMITH.

MONKREDDING, KILWINNING.
December 15, 1898.

FORAMINIFERAL FLINT FROM SOMALI.

SIR,—The Rev. R. Ashington Bullen, F.G.S., lately lent me some stone implements (labelled as having been collected by Mr. Seton-Karr in Somali, Eastern Africa), for exhibition before the Anthropological Institute, in illustration of my paper on large African stone implements (see Journ. Anthrop. Institute, new series, vol. i, 1898, p. 48). Some of these Somali implements are composed of quartzite, rather ferruginous, gritty, and hard, though the grains are only cemented at their peripheries, and not closely compact; others are of flint, coarse-grained by the visible presence of the minute organisms originally constituting the limestone of which the flint is a more or less perfect pseudomorph, still to a great degree calcareous. Many microzoa, chiefly internal casts of Foraminifera, stand out on the roughly weathered surface, and numerous sections of these organisms are seen in the fractured stone. Some friends have examined the specimens with me, and although at first I suspected small Nummulites to be present, we cannot find any certain evidence of them. Mr. Frederick Chapman, A.L.S., favours me with the following list of Foraminifera, which he has determined on the weathered surface of the flint on one of the Somali implements:—

Operculina, sp. with rib-like septa, common.
Heterostegina depressa, D'Orbigny, a very good specimen.
Cristellaria, two species, frequent.
Pulvinulina, one specimen.

I agree with Mr. Chapman in regarding the rock as being probably of Miocene or Pliocene age. T. Rupert Jones.

NOTE ON *DINOCYSTIS BARROISI.*

Sir,—Please allow me a few words in reply to the valuable paper of Mr. F. A. Bather on *Dinocystis Barroisi.*[1] In his paper "Sur l'étage devonien des psammites du Condroz en Condroz" (Bull. Acad. des Sci. de Belg., 1875, 2e sér., t. xxxix, pp. 658–9), Mr. M. Mourlon mentions, from Mr. Malaise's collection, an "astérie" found near Walcourt in an indeterminate "assise" of the "psammites du Condroz." This fossil is no longer quoted in the list of the fossils of this series, given by the same author in his "Géologie de la Belgique," but it is replaced (t. ii, p. 23) by *Agelacrinus*, very rare, in the "assises" of Montford and Évieux, the two *upper* assises of our Psammites du Condroz, and this is supposed by Mr. Bather to be the same as his *Dinocystis Barroisi.* Now the "astérie" of 1875 elevation. By referring to my letters published in September and November last your readers can see for themselves whether these statements are true or false. Dr. Spencer must have read my remarks so hastily that he failed to understand the drift of my argument, and perhaps when he succeeds in realizing that I did not anywhere deny either the subsidence or elevation of the continental margins he will have the courtesy to acknowledge that he has done me an injustice.

He accuses me of "turning the correspondence into an academic disputation of the meaning of the word 'escarpment,'" and into a "flat denial of the evidence submitted by Professor Hull." I hope to show that I did neither of these things.

Ever since Mr. Whitaker carefully distinguished between the features presented by a steep slope fashioned entirely by subaerial agencies and those of a raised sea-margin or cliff,[1] English geologists have restricted the term escarpment to the former, and have thought that the primary origin of the slope was a point of some importance. Dr. Spencer tells us that by American geologists the descent from a tableland or plateau is termed an escarpment, and he implies that they do not trouble themselves to ask whether the course of the feature was determined by the sea or by subaerial agencies. Of course Dr. Spencer ought to know, and I can only express surprise at what he says is American usage.

Again, Dr. Spencer asserts that I flatly denied Professor Hull's evidence. Now most people reading such a statement would suppose that I had flatly contradicted Professor Hull on statements of fact, which is very far from being the truth. Hence I am led to ask whether Dr. Spencer has any clear conception of the difference between evidence and inference.

I could wish that Professor Hull had displayed his facts more fully by reproducing some of the actual charted records, but I did not question the accuracy of his observations, nor his inference that the submerged plateau was once a land-surface and that traces of river-valleys may be found upon it. It was not his evidence but his further and more theoretical inferences that I questioned.

What I denied, and still deny, is that Professor Hull adduced any evidence to prove that the steep declivity which forms the border of the plateau was an escarpment in the English sense of the term, in other words that it has been formed and fashioned *entirely* by subaerial agencies. Not only did Professor Hull assume that it was so formed, but he further assumed, without proof and without consideration of other possibilities, that the platform was formed first and the declivity afterwards. Further, he referred these events to definite periods of geological time. I asked him to give his reasons for these conclusions, but in his reply (October) he did not answer the two latter questions (promising, however, to discuss one of them later on), and confined himself to defending his use of the term escarpment. Is it surprising that my rejoinder was similarly limited ? and is Dr. Spencer justified in saying that I converted correspondence into an academic disputation ?

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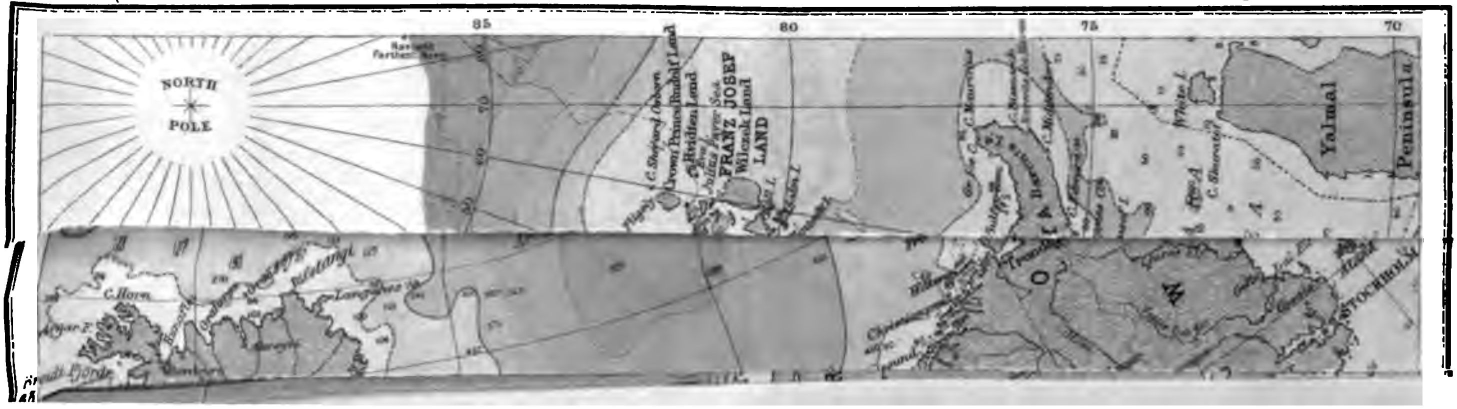
[1] GEOLOGICAL MAGAZINE, Vol. IV, pp. 447 and 483 (1867).

Because in my second letter I still denied that Professor Hull given any good reason for regarding the declivity as a feature subaerial origin, this denial is construed by Dr. Spencer into a denial of all Professor Hull's evidence. His desire apparently that Professor Hull and himself should pose as martyrs for a faith, and he hurls a defiance at any individual, council, or presid of any learned society in the universe who should venture to do or deny his interpretation of the facts !

So long as Dr. Spencer maintains such an attitude it is impossi to argue with him. I am deeply interested in the history of submerged portion of the European continent, and I look forward Professor Hull's promised consideration of it, when he will doubtl answer my questions, for he is always a courteous opponent.

I have supposed that the position of the great declivity and general course were determined by marine erosion (just as present coastline has been), and, further, that the platform betwe the modern and the ancient coastlines was formed subsequently at expense of the ancient continent. Both platform and declivity ma have been afterwards modified by subaerial agencies, and this may ha been the penultimate phase in their history, but this order of eve is not that indicated by Professor Hull. A. J. JUKES-BROWNE.

WILLIAM COLCHESTER, J.P., F.G.S. This well-known geologist, so long connected as Chairman with Messrs. Lawes' Chemical Manure Company, of the Manganese Bronze and Brass Company, and Senior Partner in Messrs. Colchester and Ball's Chemical Manure Manufactory, who had attained to the advanced age of 85 years, died at his residence, Burwell Hall, Cambridgeshire, on the 16th November, 1898. We shall give an obituary of Mr. Colchester in our March Number


85
80
75
70
NORTH
POLE
Farthest North
C. Sherard Osborn
Crown Prince Rudolf Land
Rainer Land
Julius Payer Sea
FRANZ JOSEF
Wilczek Land
LAND
C. Mauritius
C. Nassau
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White I.
C. Sherostin
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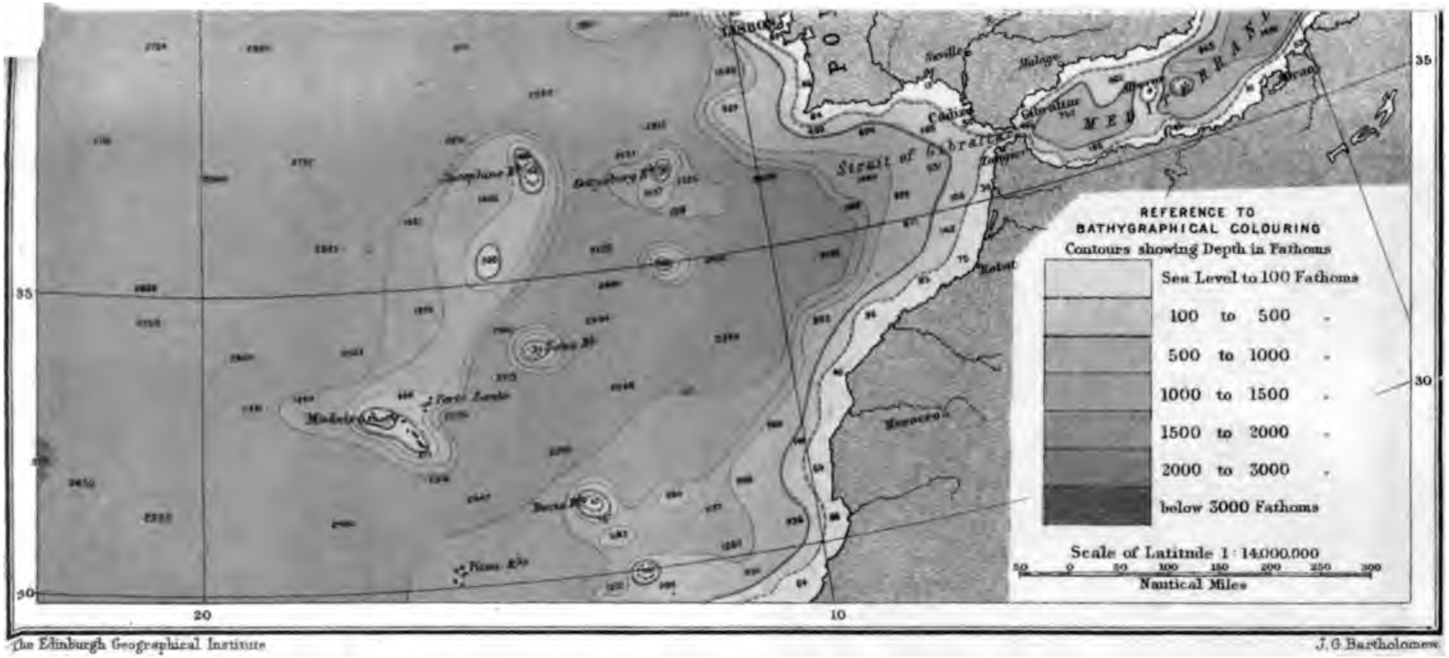

FIG. I. THE EASTERN MARGIN OF THE NORTH ATLANTIC BASIN.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. III.—MARCH, 1899.

ORIGINAL ARTICLES.

I.—On the Eastern Margin of the North Atlantic Basin.[1]

By Wilfrid H. Hudleston, M.A., F.R.S., F.L.S., F.G.S., etc.

(PLATE III.)

In offering a few remarks on a subject which belongs, in the first instance, to the province of physical geography, it will be necessary for me to point out certain hydrographical details, whilst endeavouring to deduce from these details conclusions having a geological bearing. Oceanography is almost a science in itself, especially if we regard it from a geological point of view, as something more than a mere description of water-spaces and soundings. Ever since the days when the deep oceans were first explored for the purpose of laying the telegraph cables some of the leading facts were made known, and have since become familiar to all students of physical geography. Such a feature, for instance, as the Continental shelf, usually called the 100-fathom platform, which supports the British Isles, the German Ocean, and its backwater, the Baltic, has long since been made clear to us by the cartographer.

The width of the submerged Continental shelf is very considerable within the area of the British seas. It is generally considered to represent a plane of marine denudation sloping gradually outwards towards an 'edge,' which is approximately represented by the 100-fathom contour, although the real edge sometimes lies rather deeper. This 'edge' is an important feature, since it indicates the angle made by the Continental shelf with the *suboceanic Continental slope*, leading down into the oceanic abyss—what the late Dr. Carpenter might have called the rim of the 'Tea-tray.'

It is to this suboceanic Continental slope that I would chiefly direct your attention, so far as it constitutes the eastern margin of the Atlantic basin. Our limit on the south, for convenience, is the 30th parallel of North latitude; and some approximation to the suboceanic slope may be traced, in varying form and with great difference in the angle of inclination, from the west coast of Africa to the north-west of Spitzbergen. Its mean direction is slightly west of the meridian of Greenwich, with a divergence of about 12° of longitude on either side. This direction it maintains for 51° of latitude, or about 3,500 statute miles. From off the north-west corner of Spitzbergen the suboceanic Continental slope trends easterly, passing north of Franz Josef Land and the New Siberian Islands.

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[1] Read in abstract at the Meeting of the British Association, Bristol, Sept., 1898.

The persistent physical feature which I have called the *suboceanic Continental slope* has been variously described as a 'submerged bank,' and even as an 'escarpment,' though it is certainly not likely to be an 'escarpment' in the geological sense of the term. Before proceeding to trace this particular margin of the north-eastern Atlantic basin, it may be of service to consider some of the remarks of Professor Milne with reference to suboceanic continental slopes generally. These are to be found in his very suggestive paper on "Suboceanic Changes."[1]

Just as we owe the beginning of oceanography to the surveys which preceded the laying down of telegraph cables, so we are likely to learn something about suboceanic movements owing to the repairs which these cables require. Professor Milne brought this subject before the Royal Geographical Society in 1897, and his remarks regarding suboceanic continental slopes are exceedingly important. After referring to submarine banks and ridges generally, he points out that we have evidence of sudden changes in the details of suboceanic contours in the steep slopes flanking the submarine platforms which fringe continents and islands. The causes of suboceanic yielding in rocks and sediments are twofold. The most important is what he calls 'bradyseismical' action, represented by secular folding, thrust, or crush; sudden acceleration in these movements constitute earthquakes, which may be accompanied by a line of fault and landslips. A second group of causes is referred to sedimentation and erosion: these create unstable contours, which may be destroyed by seismic action or in other ways. He calculates that one-half of the earthquake shocks occurring throughout the world have their origin in the suboceanic continental slopes. He divides these into *seismic* and *non-seismic* districts. Slopes of considerable horizontal extension—say 120 geographical miles—which are steeper than 1 in 35 ($1\frac{3}{4}°$), are likely to be the seat of submarine earthquakes accompanied by landslips. As examples of seismic districts he instances the west coast of South America, the Kurile Islands, and parts of Japan; whilst of non-seismic districts he instances the coasts of Australia, Scotland, and South Norway.

Seismic strain, due to a tendency in the earth's crust to further adjustment, is greatest where earthquakes most frequently originate; and the special home of the earthquake is at the base of the steep oceanic slopes, where most deformation is in progress. He further observes that the results of vertical movements are those which are now most apparent, but that the *geotectonic structure* of many countries shows great horizontal displacement likewise.

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[1] Geographical Journal, August and September, 1897.

It will be gathered from the preceding extracts that Professor Milne regards the suboceanic continental slope as an important factor in the tectonic history of the earth's crust. Looking at the subject broadly, one might say that this suboceanic slope performs a double function. In the first place, as the more or less abrupt termination of a continental mass, it affords relief to the periodic strain, and thus becomes at times the seat of dynamic energies of great force. Secondly, its more obvious function is to contain all but the surface waters of the great oceans within its limits, and it thus becomes the true margin of their respective basins.

Trusting to be pardoned for what might seem at first sight a digression, I will now direct attention to a few hydrographic details with reference to the particular suboceanic slope under consideration. We have already seen that it extends over 51° of latitude. Allowing for sinuosities and for the easterly extension beyond Spitzbergen, we are dealing with a marginal line which cannot be less than 5,000 miles in length. The principal authorities for these details, and also for the accompanying map, are as follows:—

Nansen's paper "On some Results of the Norwegian Arctic Expedition."[1]

"The Physical Chart of the North Polar Regions," by Bartholomew.[2]

"The Norwegian North Atlantic Expedition," by H. Mohn.[3]

And lastly, several of the British Admiralty charts, e.g.:

Chart No. 1, "British Islands to Mediterranean Sea," published in 1884, with small corrections down to 1897.

Chart No. 2, "The British Islands," published in 1884, with small corrections down to 1894 and large corrections down to 1896.

Chart No. 1,104, "The Bay of Biscay," published in 1888, with large corrections down to 1892 and small corrections to 1897.

Chart No. 2,058, "North Atlantic Route Chart," published in 1892, with small corrections down to 1897.

Also other Admiralty charts.

It must be understood that the accompanying map has no claim to accuracy of detail; if a general impression is conveyed, that will be sufficient for the purpose.[4] The 'edge' or angle between the

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[1] Geogr. Journal, May, 1897. [2] Ibid., June, 1897. [3] Christiania, 1887.

[4] This remark refers to the large chart which was exhibited at the Bristol meeting. Since then Messrs. Bartholomew have prepared a more elaborate map based upon the outlines of that chart. This will serve to give a *general idea* of the subject of the paper, viz. "The Eastern Margin of the North Atlantic Basin." It will be readily understood that details can only be shown on a larger scale. Indeed, for very close work in connection with the "*suboceanic Continental slope,*" it may be doubted whether a sufficient number of reliable soundings have been taken as yet to warrant any detailed mapping of these slopes in some cases. Notwithstanding the imperfection of the record, however, there are some features in the marginal line, such as the 'Fosse de cap Breton,' which have been clearly established (see Fig. 4). It will be observed that a very small area in Messrs. Bartholomew's chart, to the W.S.W. of Madeira, shows depths exceeding 3,000 fathoms. This, however, has no bearing on the subject of my paper.

Continental platform and the suboceanic slope varies as to degree of submergence, being mostly on the 100-fathom contour in the British seas, but nearer the 200-fathom contour off parts of the Norwegian coast.

PART I.—THE NORTH POLAR OCEAN, AND THE NORWEGIAN ATLANTIC.

Since the most important recent results in oceanography have been obtained in the North Polar basin, it seems only proper to commence our bathymetrical studies in the far north, and to work our way southwards as far as the limits already indicated. The results obtained by the "Fram" were so contrary to what was generally expected, that it may be some time before their true import is fully realized. They prove beyond doubt, however, that the Atlantic depression, which we knew was continued into the Norwegian Atlantic and thence through the ocean narrows between Greenland and Spitzbergen, expands in the North Polar area, and in all probability extends to the Pole itself on the meridian of Greenwich. Nansen tells us that he had imagined the Polar basin, taken as a whole, to be shallow, but he found the sea north of the New Siberian Islands suddenly becoming deeper and sinking to a depth of 1,800 to 2,000 fathoms, and that this depth was maintained during the entire drift of the "Fram" as far as north of Spitzbergen. He therefore takes it for granted that the Polar basin is a deep sea, which forms a continuation northwards and eastwards of the same depth as the Northern Atlantic Ocean; he concludes that there is little or no land on this side of the Pole, and this conclusion is based on several considerations of great weight.

According to old soundings taken long before the voyage of the "Fram," a depth of 1,370 fathoms is recorded about 100 miles north of Spitzbergen; and this might have been accepted as an intimation of what was to be expected further eastwards. We can believe that the "Fram" crossed a suboceanic slope in about 79° N. lat., and that this slope will be found to extend all along the northern margin of the shallow platform which supports the Franz Josef Archipelago, itself only an eastern extension of the Spitzbergen group.[1] This platform bears the same relation to the north of Europe that the British platform does to the north-west of Europe. The chief difference lies in the fact that the mouth of the Barents Sea, between Bear Island and the North Cape, is deeper than the average edge of the North Sea platform by about 170 fathoms, though the eastern parts of the Barents Sea are shallow enough.

A few of the details of the Norwegian Atlantic may next be taken into consideration. The several parts of this have received different names, but it may be regarded as practically one basin in alignment with the North Atlantic Ocean. The major axis of the principal deeps is for the most part meridional, and, indeed, lies almost exactly on the meridian of Greenwich. The most remarkable depth is that known as the Swedish deep. attaining 2,650 fathoms in the narrows about midway between Spitzbergen and Greenland. The average slope of the sea bed here is stated by Mohn to be 1 in 129, or less than half a degree; but such a general statement gives no idea of the inclination of the marginal slopes off the west coast of Spitzbergen. Thus, about 50 miles from the shore, off the mouth of Ice Sound, the edge of the Continental platform is well marked in 120 fathoms, and succeeded by a rapid marginal slope towards the abyss. From Sydkap to Bear Island the suboceanic slope is fairly well marked, the edge being mostly in 200 fathoms. Off the mouth of the Barents Sea the slopes are gentle, the edge being in about 280 fathoms. But as we approach the Lofodens the contours begin to draw in much closer, and the steepest part of the suboceanic slope off the coast of Norway occurs hereabouts (Vesteraalseg). The depth increases from 100 to 1,500 fathoms in a distance of 22½ nautical miles, giving, according to Mohn, a slope of 1 in 16 or 3½°. The general Norwegian submerged shelf, as before observed, has its edge near the 200-fathom contour, which runs rather far out to sea and again curves towards the land opposite Romsdal; on the other hand, the 100-fathom line hugs the coast of Norway pretty closely.

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[1] Since Dr. Koettlitz records (Quart. Journ. Geol. Soc., vol. liv, p. 644) a depth of 230 fathoms thirty miles west of Cape Mary Harmsworth, it is possible that a bight of the deep North Polar ocean may extend for some distance between the Franz Josef Archipelago and Spitzbergen.

The Norwegian Channel, sometimes called the River of Norway, is a curious feature, whose origin has given rise to a considerable amount of discussion. As a matter of fact it is a depression of considerable width, which laps round the southern lobe of Norway from the Skager Rack to beyond the mouth of the Sogne Fjord. It has also, I believe, been called the 'River of the Baltic,' and regarded as the submerged channel of a watercourse which once drained the Baltic area when that was dry land. Unfortunately for this theory the deepest part of the Norwegian Channel lies in the Skager Rack off Arendal, where a depth of 443 fathoms is recorded by Mohn, whilst the Channel is only 160 fathoms deep off Bergen on the Atlantic side, between Norway and Shetland. The 'River of the Baltic,' therefore, must have had some difficulty in draining towards the Atlantic under these circumstances.

Speaking generally, one would say that the basin of the Norwegian Atlantic is more spoon-shaped than that of the British Atlantic: in other words, the marginal slopes appear to be less steep on the whole. A low transverse elevation runs in a north-easterly direction from Jan Meyen to Bear Island, almost athwart the main meridional depression; Jan Meyen Island itself is a huge volcanic pimple. The steepest decline in the Norwegian sea was found north-west of this island, where the depth reaches 1,040 fathoms at a distance of only seven nautical miles from the land, corresponding to a slope of 1 in 7, or 8°, being the direct continuation of the lava slopes of the extinct volcano called the Beerenberg. On the south side of the island the slopes are more gradual. It is evident that in course of time this volcanic mass must have displaced an enormous volume of water, and unless there was a corresponding sinking-in somewhere, some perceptible effect must have been produced on the sea-level. I might mention here that in Mohn's admirable work a number of serial soundings are given throughout the Norwegian Atlantic. These of necessity are drawn with the vertical scale much exaggerated. In this way even the central deeps may be made to look like cañons with V-shaped valleys at the bottom. This is especially the case in the deep-sea between Spitzbergen and Greenland, and it is easy to make a slope of 3° or 4° look almost vertical. In the southern part of the Norwegian Atlantic the *average* rise of the sea bed from its greatest depths towards the coast of Iceland, the Færoes, and Norway is stated to be 1 in 188, or about one-third of a degree.

Before proceeding any further south with our bathymetrical survey, we ought to consider the geological bearing of the details already given, as far as practicable. It is obvious from an inspection of the accompanying map that the eastern part of the North Atlantic, the Norwegian Atlantic,[1] and a portion of the North Polar ocean all belong to one and the same great geosynclinal depression, which has been partly interrupted by volcanic extravasation, more especially in the region between Shetland and south-east Greenland. This linear arrangement of what I may call, in general terms, the North Atlantic oceanic depression, extending from the North Pole in the direction of the Equator, seems to call for some explanation on physical grounds. We are reminded of the two principal schools of geographical evolution, and of the theories relating to the permanence or non-permanence of the major features of the earth's crust. Ever since the leading facts of oceanography were made known there has been a tendency in some quarters to regard the great oceans as permanent features. If this is really the case, then the suboceanic continental slopes would, under certain limits, come to be regarded as permanent also.

Dana and Wallace have argued strongly in favour of the permanence of the great features of the distribution of land and water on the earth's surface, but the majority of geologists in England have rather clung to the Lyellian doctrine as to a complete change of land and sea having taken place at various periods of geological time. The secular interchangeability of the great land and water areas has also received much support from the view that the Chalk is of necessity a deep-water formation—abyssal according to some. Wallace,[2] it is well known, considered that the doctrine of the permanence of continents and oceans lay at the root of all our inquiries into the past changes of the earth and its inhabitants. He thought that this doctrine received strong confirmation from the evidence adduced by Darwin, who observed that hardly one truly oceanic island had been known to afford a trace of any Palæozoic or Mesozoic formation; so that islands of this class have not preserved a fragment of the supposed ancient continents, nor of the deposits which must have resulted from their denudation.

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[1] In Bartholomew's map (Fig. 1) the northern part of the Norwegian Atlantic is called the 'Greenland Sea.'

[2] "Island Life."

Unless this reasoning has been upset by fresh evidence, it ought to have considerable weight with geologists. No doubt some of the West India islands, and notably Barbados, afford examples of oceanic deposits of Tertiary age resting upon terrigenous deposits known as the Scotland Beds. Nevertheless, even Barbados lies inside the true suboceanic continental slope which margins that side of the Atlantic, whilst the Caribbean Sea may be regarded as a region of exceptional oscillation, which partakes to some extent both of an oceanic and a continental nature. The Mediterranean in a less degree presents similar features, and it seems to me that no valid argument can be based on events which have occurred or are occurring in such abnormal areas.

Another very specious argument against permanence is derived from the great height to which marine Tertiary beds, such as the Nummulitic, are raised in the Alps, Himalayas, etc. Why may not changes of equal magnitude, it is urged, have taken place conversely in areas now occupied by the great oceans? It should be borne in mind, however, that the upheaval of Tertiary marine beds to these great heights naturally takes place in mountain ranges, where tangential pressure is at a maximum along lines which are of great length but very limited in width. Such features can hardly be compared with the great ocean expanses, whose breadth is measured by thousands of miles. On the other hand, there is a considerable degree of analogy between these prolonged mountain ranges and the suboceanic continental slopes which bound the great oceans. Both classes of phenomena are largely due to tangential pressure, the result of secular contraction. Hence for the most part mountain ranges are believed to occur and reoccur with nearly the same orientation throughout geological time. They form the lines of adjustment, as it were, in the earth's crust, which became especially acted upon at certain epochs; and the fact of marine Tertiary strata having been raised to heights ranging up to 20,000 feet, although it shows oscillation to a great extent within a long and narrow area, does not justify the idea of an equal amount of oscillation in the ocean basins.

The principal region of vertical movement in connection with the oceans is probably to be sought in the suboceanic continental slope, and such movements would affect the shelf or continental platform more than the abyssal floor, which would remain comparatively unaffected. In this way the upper portions of the submarine slopes on the sides of the Atlantic may have emerged at times along the line, more in some places and less in others, thus constituting saliences which were worn back by the planing action of the sea; and in this way the Continental shelf, or rather portions of it, may be of considerable antiquity.

If this view be correct it will allow for a considerable amount of change throughout geological time on the margins of the great oceans without materially affecting the ocean basins themselves.

We may thus regard the crust of the earth as still retaining traces of its congenital features in the shape of the great ocean depths, and also in the position of the chief continental areas which have been built up from deposits formed for the most part in shallow seas, though with some important exceptions. On the question of the primal origin of these features we obtain some valuable physical hints from Lord Kelvin[1] in his remarks on that very critical stage in the earth's history when solidification was commencing on the surface. His view is that continents and ocean depths were due to heterogeneousness in different parts of the liquid which constituted the earth's surface before such solidification. The hydrostatic equilibrium, he says, involved homogeneousness in respect to density only, but none in respect of chemical composition: from this heterogeneousness the irregularities of the present surface, he thinks, followed by dynamical necessity.

No apology is needed for quoting the views of one of the first physicists of the day as to the possible origin of some of the major features of the earth's crust. But it is time, after this diversion, to consider the bearing of Nansen's discoveries in reference to theories of geographical evolution. As already pointed out, the northern boundary of the European continental platform must be sought in Spitzbergen and the Franz Josef Archipelago. At present every detail in connection with this prolongation of the eastern margin of the Atlantic basin is wanting. We know that a shallow sea becomes a deep one, and that is all. But the question arises as to how long in the history of the earth has this feature endured? Is a deep North Polar ocean one of the permanent features of the earth's crust?

There are no people so ready to make light of the problems of geographical evolution as the biologists. Whenever a botanist or a zoologist is desirous of explaining the peculiarities of distribution, he is quite ready to conjure up a continent from "the vasty deep." Thus, it is not so long since we heard of a famous botanist requiring a large land area in the Polar ocean. But in the light of recent discoveries we may feel certain that no such land area exists at present; whilst the great depths recorded by the sounding-lead render it unlikely that land has existed there so recently as to have influenced plant distribution. Even supposing that Greenland belongs botanically to Europe, it is not in the North Polar area that the connection is likely to have been made. Speaking generally, one might say that, since the sea is in possession of the depths, the *onus probandi* rests with those who would alter the condition of things. Apart from mere surmise, it is by no means easy to prove that a water-space has ever been a land area, though of course the converse of the proposition presents no difficulties. We have abundant evidence that, on the continental side of the suboceanic slope, there have been oscillations of moderate amount, resulting in the formation of terrigenous deposits of many ages in connection with what is now the shallow Barents Sea. If any volcanic island, outside the continental slope, could be shown to contain deposits resulting from continental degradation, it would be difficult to maintain that no dry land had existed where now are oceanic depths; but failing such evidence as this, we must be content to regard the deep Polar ocean as a permanent feature.

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[1] Annual Address to the Victoria Institute for 1897.

Again, as a more especial argument for breaking up the existing North Polar basin, it has been pointed out that the strike of the rocks and the trend of the mountain chains for the most part run north and south, ending abruptly on its margin. The idea is that these mountain chains, having what is called a 'Ural orientation,' once extended further north, and have in some unaccountable way been removed or cut short. Undoubtedly, we know so little of the true termination of these highland areas that no theory can safely be founded on their apparent truncation. There are, however, other regions where a mountain range is obviously truncated by the sub-oceanic continental slope—notably the Cantabrian chain in the north of Spain, which may be said to disappear suddenly in 2,000 fathoms of water. As a possible explanation I would suggest that such disappearance is due to tectonic failure in the process of mountain-making, such mountain-making being especially connected with continental elevation. On approaching the margin of an oceanic area another set of tectonic conditions prevails. In this way the mountain range fails from internal causes, and, therefore, any theory accounting for its removal becomes superfluous.

(*To be continued.*)

II.—Notes on the Geology of West Swaziland, South Africa.

By Professor T. Rupert Jones, F.R.S., F.G.S.

Mr. SYDNEY RYAN, of Darkton, Managing Director of the Ryan Tin Mines, situated on the Embabaan River in West Swaziland, has collected and sent to England a large collection of rock-specimens from the Ingwenya Berg, the dominating feature of the district. He has also provided plans and sections of the district, which are here partly reproduced. The specimens have been presented to the Mineralogical Department of the British Museum, together with a complete catalogue, having reference to the Sections referred to above, and indications of the lithological characters of the 140 specimens.[1] Mr. G. Th. Prior, F.G.S., has kindly aided the writer in the critical examination of the rocks, and is communicating a description of those of economic value to the forthcoming number of the Mineralogical Magazine. They include niobates and titanates of the rare earths, chemically allied to Euxenite and Fergusonite, Monazite containing Thoria, Cassiterite crystals of peculiar habit in matrix, Corundum, and Scheelite.

Our friend Mr. John Ballot, F.G.S., who knows Mr. S. Ryan and the district very well, has favoured the writer with much information,

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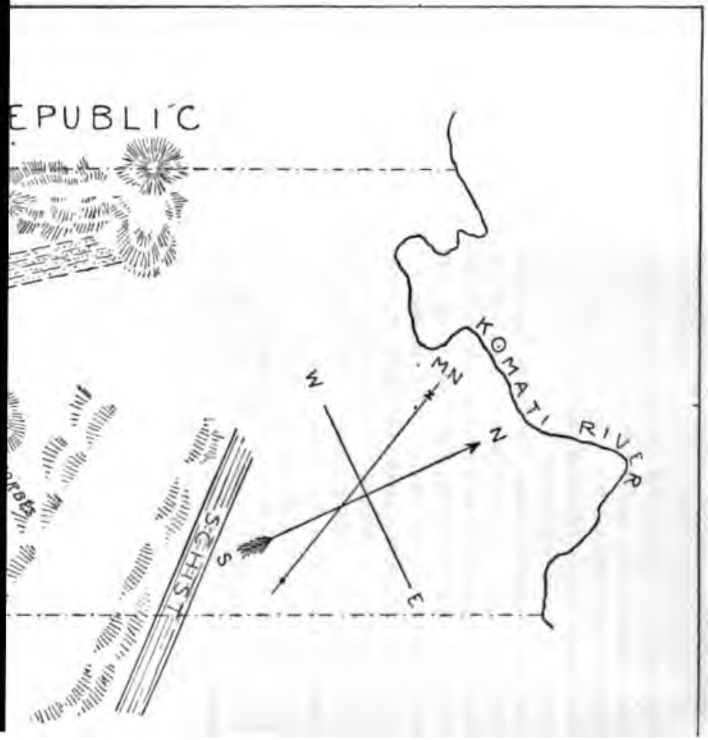
[1] The specimens, labelled and numbered, are individually referred to as belonging to the several divisions of the three great sections, X, T, Z, at the end of this paper, with some unavoidable irregularity in the successional numbers. (See pp. 110, 111.)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both from his own knowledge and from communication with Mr. Ryan, who has a clear notion of the structure of the district, as shown by his plan and sections.

In the course of his researches in the tin-bearing gravels of the Embabaan, Mr. Ryan found some very fine stone implements, made and used by earlier occupants of the country. He also discovered the rock, *in sitû*, of which these ancient tools were made. These large South African implements have been described and illustrated in the Journal of the Anthropological Institute, new series, vol. i (1898), pp. 48–54, pls. iii and iv. They consist of varieties of the grey and black lydianized and mylonized grit and breccia of Section T, division c, which passes along near the middle of the Ingwenya Berg, as a constituent of the western limb of the great syncline in that mountain range.

The chief feature observable in Mr. Ryan's plan of the Forbes Reef Gold-mining Company's property, Fig. 1, and in the Sections, Figs. 2 and 3, is the occurrence of a great syncline of various schistose rocks in the Ingwenya Berg. This is traversed by Sections Z and T, from S.S.E. to N.N.W. (70,000 feet, about 13¼ miles), and further to the south-west by the nearly parallel Section X (on the Ryan Tin-mining Company's property), which repeats some part of Section T, and reaches further to the west into the Transvaal (see Fig. 1).

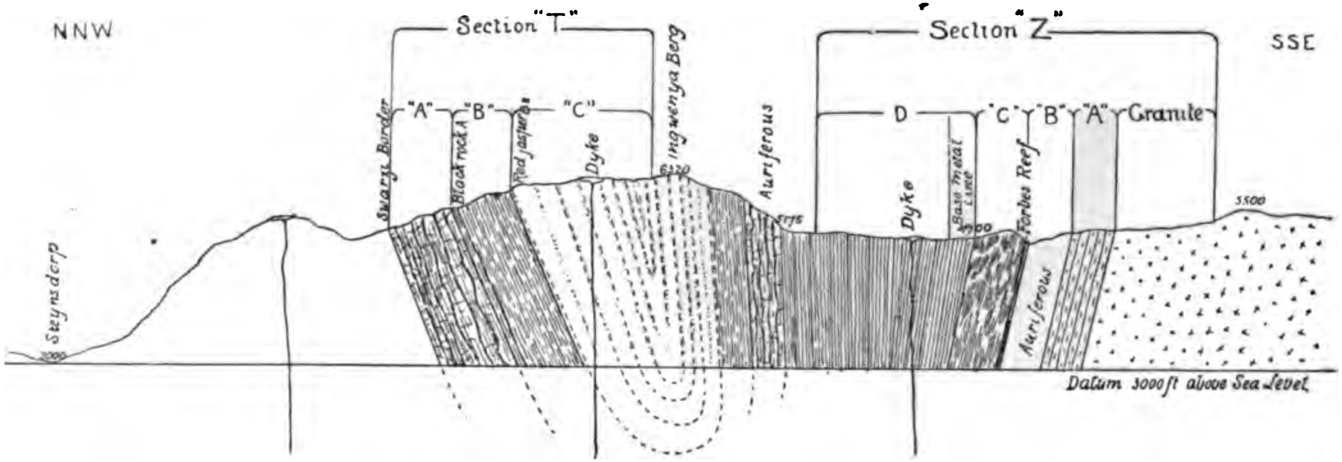
Section Z (Fig. 2), reaching from the granitic hills on the S.S.E. border of the Forbes Reef Gold-mining Company's property, passes across the Ingwenya Berg, and is continuous on the N.N.W. with the Section T (Fig. 2), which reaches the western limit of the same property, conterminous with the Transvaal.

Section T is continuous on the N.N.W. with Section Z, and meets the Transvaal border at about 63,750 feet (about 12$\frac{1}{12}$ miles) from the south-western angle of the Forbes Reef Gold-mining Company's property.

Section X (Fig. 1), running west and east, is 65,625 feet (about 12½ miles) south of Section T, and at an angle of 45° with it, and parallel with a part of the south boundary of the Forbes Reef Gold-mining Company's property, which divides it from the Ryan Tin-mining Company's property.

Between Sections Z and T a narrow space, about 5,655 feet (more than a mile) broad, on the N.N.W. half of the Ingwenya Berg and passing nearly north and south, is coloured yellow and marked "conglomerate" on Mr. Ryan's plan of the Forbes Reef Gold-mining Company's property (Fig. 1). This band corresponds with the division c of Section T, about 5,000 feet broad (specimens Nos. 83–96), belonging to the western limb of the local syncline. The highest part of the Berg (6,321 feet) is a prominent part of the eastern limb. This "conglomerate" evidently passes through the southern boundary of the Forbes Reef Gold-mining Company's property. Its northern extent is not defined on the plan further than 22,500 feet (about 4¼ miles) north of Ingwenya Berg summit. The division c of Section T consists of hard grit and breccia of lydite,

FIG. 2.—Section along the line on Map, Fig. 1, marked T-Z, in the Forbes Reef Gold-mining Company's Property, Swaziland. (See ante, p. 106.)



rtz-rock, and some jasper, with siliceous cement. Some of the terials of this rock have been greatly squeezed, crushed, and lonized.

[f the strata of Section T be continued with the same strike as t shown by the "conglomerate" band (which in Mr. Ryan's n of the Forbes Reef Gold-mining Company's property passes liquely across the Ingwenya Berg on the western side of the mmit, Fig. 1), through the Section T towards X, the strata T B ay be found in X G, and T A in X F, as the latter section trends stward; and, further, X D, C, B, and A continue the succession on the granite in the Transvaal. These beds in Section X (Fig. 3) ip to the east, at a high angle; and are evidently not only onformably continuous with the "conglomerate" band of the plan (that is, the breccia of T C, Fig. 2), but with the whole of the great syncline.

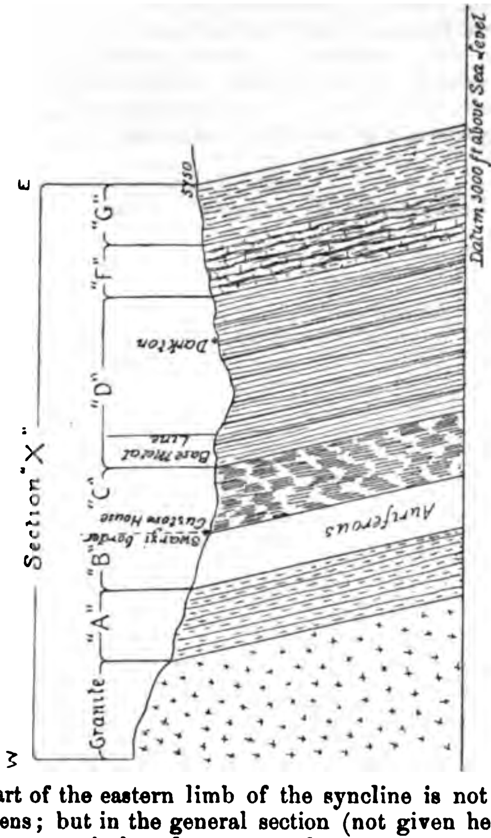


FIG. 3.—Section along the line marked X on Map, Fig. 1, in the Ryan Tin-mining Company's Property, Swaziland. (See ante, p. 106.)

A part of the eastern limb of the syncline is not represented by pecimens; but in the general section (not given here) it is shown be more vertical, and consequently more compressed. Moreover, is immediately succeeded on the S.S.E. by a repetition of T B and

T A, as parts of the same syncline. Further on, Section Z, divisions D, C, B, and A, conformably succeed, the last resting against gneiss and granite.

In Section X, its eastern divisions G and F are the equivalents of T B and A, and these are succeeded by the equivalents of Z D, C, B, and A, in succession, as far as the granitic rocks on the west. It thus constitutes the western portion (about 15,500 feet, less than three miles) of the syncline, the diameter of which is about 45,000 feet, or about 8½ miles.

The strike of the schistose rocks on the eastern side of the syncline of Ingwenya Berg, if continued, would lead them into the Kaap River Goldfield, as part of Schenck's Swaziland schists.

Mr. Ryan has discovered a place where the natives in ancient times made their stone implements by chipping, the relics of flakes being there in abundance. This locality is on the north-west face of the Makonjwa Range, which is a northern continuation of the Ingwenya Berg. It is shown in Mr. Ryan's map of the district as being on the eastern border of the Kaap River Goldfield, and about six miles south-east of Barberton, where more or less dressed flakes of black siliceous schist, together with others, have been found.

Western half of the syncline.

SECTION X (Fig. 3).
A, 97–103. Micaceous, hornblendic, and actinolitic schists ... ... = Z A
B, 104–106 and 124. Talcose schists. 'Auriferous' ... ... = Z B
Swazi Border, Custom House.
C, 107–111. Quartz-schist and gneiss ... ... = Z C
D {Base metal line.
112–123. Quartzite and quartz-schists, some talcose ... ... = Z D
F, 128–131 and 125–127. Micaceous quartz-schist, phyllite, and hæmatite ... ... = T A
G. (No specimens.) ... ... = T B

SECTION T (Fig. 2).
Swazi Border.
A, 38–56. Black siliceous schist (lydite), banded with quartz-schist, argillaceous schist, talcose, micaceous, and hornblendic schists = X F
B {Black rock, marked 'A.'
57–82. Argillites, siliceous schists (some black), micaceous schists, and banded quartzite, jasper, and hæmatite ... ... = X G
C {Red jasper, marked 'B B.'
83–96. Siliceous grit and breccia, lydianized = "conglomerate" band in Fig. 1.

Eastern half of the syncline.

Here is a repetition of T C, T B, and T A, in part of the eastern limb of the syncline.

SECTION Z (Fig. 2).
D {35, 36, 17–19, 37, and 34. Talc-schist and quartzite ... ... = X D
Base metal line.
C, 31, 16, 32, 33. Micaceous schist and decomposed gneiss... ... = X C
Forbes Reef—auriferous.
B, 7–10, 30, 12–15. Serpentine and serpentine-schists. 'Auriferous' = X B
A, 4–6 and 11. Quartzite and mica-schist (No. 4) ... ... = X A
1, 1, 2, 3. Gneiss (fine- and coarse-grained) ... ... = X 'Granite.'

The illustrations accompanying Mr. S. Ryan's specimens are:—

1. **Map of the country between the Transvaal and the Indian Ocean from 25° 30′ to 27°.**
2. **Section across the country from Steynsdorp to the Indian Ocean.**
3. **Fig. 1.—Plan of the Forbes Reef Gold-mining Company's property in Swaziland, including the lines of Sections Z and T, and Section X in the Ryan Tin-mining Company's property at Darkton. (See p. 106.)**
4. **Fig. 2.—The Sections T and Z in the Forbes Reef Gold-mining Company's property. (See p. 108.)**
5. **Fig. 3.—The Section X in the Ryan Tin-mining Company's property (p. 109).**

III.—The Age of the Vale of Clwyd.

By A. Strahan, M.A., F.G.S.

For many years the New Red Sandstone of the Vale of Clwyd was shown upon the maps as resting generally on Carboniferous Limestone, but frequently overlapping it so as to pass on to the surrounding Silurian strata. No faults were indicated, and the structure of the Vale, as represented, suggested that a pre-Triassic syncline here existed, within which a remnant of Carboniferous rocks had been preserved from denudation and which had formed a bay in the Triassic coastline.

In 1880, however, when Sir A. Ramsay was engaged upon the second edition of his Memoir on North Wales (vol. iii of the Memoirs of the Geological Survey), doubts had arisen respecting the correctness of the map, and I received instructions to make a preliminary examination of the margins of the Vale. This I did in company with Mr. Aveline, and the results were used by Ramsay in writing chapters xxxii and xxxiii of the memoir referred to.

Subsequently the resurvey of Flintshire on the six-inch scale, which was then in progress, was carried so far as to include the whole of the Vale except its extreme southern end and a portion of its western side lying south of Denbigh. The western side north of Denbigh was surveyed by Mr. Tiddeman, and the remainder by myself. A description of the geology appeared in the Memoir on Rhyl, etc. (1885), so far as related to Quarter-sheet 79 N.W., and in the Memoir on Flint, etc. (1890), so far as related to Quarter-sheet 79 S.E. The Quarter-sheets 79 S.W. and 74 N.E. were also brought up to date in 1895, so far as was possible without a complete resurvey.

Briefly stated, the results of the resurvey went to show:—That two subdivisions of the Carboniferous system were represented in the Vale, namely, the Carboniferous Limestone and some purple sandstones and shales lying conformably upon it[1]:—That these strata

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[1] Although lying outside the subject of the present paper, the history of these strata deserves a brief notice. They were first distinguished from the Trias in 1865 by G. Maw (Geol. Mag., Vol. II, pp. 380, 523, and Rep. Brit. Assoc. for 1865, Sections, p. 67), but erroneously described as Permian. In the same year D. C. Davies suggested that they would probably prove to be Carboniferous (Geol. Mag., Vol. II, p. 476). During the resurvey of 1881 it was readily seen that the purple measures lay directly and conformably upon the limestone, but were unconformably overlapped by the Trias. They were known, moreover, to contain thin seams of coal, and to include strata indistinguishable in tint or character from Coal-measures. Their

were faulted down against the Silurian rocks all along the eastern side of the Vale by a great compound fracture, to which the name of "Vale of Clwyd Fault" seemed suitable, and were repeatedly displaced on the western side of the Vale by a series of what seemed to be branches from that great fracture:—That the Trias nowhere overlapped the whole of the Carboniferous, as formerly supposed, but generally rested upon the purple strata; though it frequently overlapped them and a considerable part of the limestone also, it was never directly in contact with the Silurian rocks, except where faulted against them:—That the faulting was certainly in part post-Triassic, but that much of it had been accomplished in pre-Triassic times.

In the years 1897–98 Mr. Morton[1] published the results of a detailed examination of the whole Vale, including those parts to which the six-inch resurvey had not extended, and added not a little to what was already known in a district where the prevalence of Drift and scarcity of sections makes every observation important. He concluded that the faults were wholly post-Triassic, and remarks that he "failed to find a satisfactory section showing the Trias overlapping any portion of the Carboniferous Limestone or the Purple Sandstone," and further on says that "the assumption that the faults are partly of pre-Triassic age and partly post-Triassic seems to arise from a lingering faith in the old Map of 1860, and

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Carboniferous age, therefore, was no longer left in doubt, but there remained the difficulty that they were quite unlike the rocks which lie next above the limestone in East Flintshire.

The East Flintshire Millstone Grit is of an abnormal type, for though in the southern part of the county it consists of quartz-grits and conglomerates of the usual character, towards the north it passes almost wholly into chert. With neither of these types had the purple measures anything in common, but after some little search I was able to match them exactly in some micaceous sandstones and shales which lie between the Millstone Grit and Middle Coal-measures near Mold, and which may be supposed to belong to the Lower Coal-measures of other regions. Subsequently, when the mapping showed that the Millstone Grit locally thinned out in Mid-Flintshire ("Geology of Flint," etc., p. 53), leaving the supposed Lower Coal-measures in direct superposition to the limestone, I attached more importance to the lithological affinities of the purple strata, and concluded that they also were probably younger than the Millstone Grit (ibid., pp. 33, 69).

Mr. Morton, however, states that "the Purple Sandstone and Shale, coloured as Coal-measures on the Map, are really on the horizon of the Upper Black Limestone of Prestatyn and the Arenaceous Limestone of Mold, subdivisions which do not belong to the Coal-measures" (Proc. Liverpool Geol. Soc., 1897–8, p. 280). This is true in the sense that they rest upon the "Upper Grey Limestone" of his classification, but it is not the case that they represent or pass horizontally into the black limestones. These latter are strictly local in their development, and thicken and thin rapidly in East Flintshire. In South Flintshire they are represented by alternations of sandy limestones and sandstones, and in a corresponding position in the south end of the Vale of Clwyd strata of this character, though poorly developed, are seen dipping beneath the purple beds.

This poor development, the absence of the black limestone, and the local thinning out of the Millstone Grit, may be taken with the general attenuation of the limestone as indications of a Carboniferous shore-line at no great distance westwards, the only evidence we possess that Snowdonia had commenced existence as an elevated region in Carboniferous times.

[1] Proc. Liverpool Geol. Soc., 1897–8, pp. 32 and 381.

a reluctance to supersede it by an entirely new explanation of the structure of the Vale." I would point out, however, the map of 1850 was in fact superseded by an entirely new explanation, the same which is now adopted almost in its entirety by Mr. Morton. Of this he had full opportunity of judging both from the publications on the district and from periodical inspections of my field-maps, while he was completing his field-work. We differ only on the theoretical question whether the faulting is in part pre-Triassic. That my reasons for believing it to be so have not carried conviction, makes me fear that I have not stated them with sufficient clearness.

The displacement of the Vale of Clwyd Fault, which may be anything over 1,500 feet, is usually effected by two or three parallel fractures, rarely more than 100 yards apart. The fault runs somewhat west of north on the whole, but becomes nearly north and south at its southern termination. Where there are three fractures, as often happens, the first throws limestone against Silurian, the second throws the purple beds against the limestone, and the third Trias against the purple beds. In other cases the Trias is faulted against the limestone or even directly against Silurian rocks. On the west side of the Vale the strike of the Carboniferous rocks is not along but across it. Thus they would close it in at Denbigh were they not thrown down by a large north-and-south fault, which shifts their outcrop a mile and a half southwards, and it is by several repetitions of this structure that the Vale has been carried its total length of 20 miles into the heart of the Silurian uplands. These faults, having a general north-and-south direction, presumably run into the Vale of Clwyd Fault northwards. That they were contemporaneous with it is suggested by the fact that they also obviously break through the Trias.

Although I do not know of any case where this arrangement of main fault and branches can be exactly matched, the Vale of Clwyd Fault belongs to one of the most consistently developed systems in the British Isles. The system is characterized everywhere by its N.N.W. direction. In West Cumberland the red rocks are repeatedly shifted by such faults, while they pass quite undisturbed over some huge fractures ranging S.E. to N.W. in the Carboniferous strata. The Pennine Fault, to which the Vale of Eden owes its existence, has the N.N.W. direction, and is also partly, at least, of post-Triassic age, though it follows the line of a far larger pre-Triassic dislocation. The Dent Fault is presumably of the same age. In South Lancashire the Triassic outcrop is repeatedly shifted by faults of this direction, while in North Wales there is a well-marked system of N.N.W. faults or 'cross-courses,' which are believed to be of later date than the east-and-west faults or 'lodes.'[1] The same relation holds good in Cornwall also between the cross-courses and lodes.[2] In Worcestershire and North and South Staffordshire the N.N.W. post-Triassic system is well exhibited, and includes one fracture injected with basalt of a Tertiary type.[1] In South Wales recent work has shown that the N.N.W. faults which intersect the coalfield with curious regularity are of later date than the east-and-west folds, and are in part, at least, post-Liassic. Lastly, in Somerset and Devon a similar set of faults is known to be of post-Cretaceous age, while the great disturbances and overthrusts in the Carboniferous rocks of those counties are pre-Triassic. Assuming that all these N.N.W. dislocations were contemporaneous, so far as regards their post-Triassic effects, we still can prove no more than that they are post-Cretaceous. It is probable, however, that they are principally of Miocene age, and due to the same movements which led to the fracturing of the north-west part of the British Isles and the injection into the cracks of an almost infinite number of basaltic dykes.

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[1] "Geology of Flint, Mold, and Ruthin."

[2] De la Beche, "Report on the Geology of Cornwall, Devon, and Somerset," 1839, pp. 366-7.

That the Vale of Clwyd Fault is also, in part at least, of post-Triassic age, is certain from the fact that the Trias is repeatedly shifted by both it and its branches. It is obvious, moreover, that that rock must have been tilted along the line of fault, for the current-bedding planes dip at 50° or 60° from the fault, an impossibly steep angle to be due to deposition in either air or water. The existence of pre-Triassic disturbance can therefore only be determined by eliminating the post-Triassic movements and ascertaining the position which had been assumed by the Carboniferous rocks in pre-Triassic times. This can be done by observation of the overlap of the Carboniferous by the Triassic strata.

In the north and north-eastern part of the Vale we know nothing of the relations of the two formations beyond the fact that Coal-measures, dipping steeply to the north-west, are thrown by the Vale of Clwyd Fault against the limestone at Dyserth and Meliden, while two boreholes out in the plain at Rhyl and Prestatyn proved red sandstone believed to be partly of Triassic and partly of Carboniferous age.[2] Though we have no clue to the exact origin of the measures there proved, it is obvious that they are not likely to be low down in the Millstone Grit, while they may well belong even to the Middle Coal-measures.

At Bodfari, on the other hand, it appears that the limestone must have been directly exposed to the Triassic waters, for it displays the partial conversion into hæmatite which is so commonly developed under such circumstances. The limestone, moreover, belongs to the lower part of the formation, which suggests that not only the Coal-measures but nearly all the limestone itself was here overlapped. The evidence, however, is more suggestive than conclusive.

Further south we find a narrow strip of the purple beds faulted in between the Trias and the limestone, while at Plas Draw there was in 1881 a section showing Trias unconformably banked against a little cliff cut out of purple beds. The Triassic overlap diminishes therefore from Bodfari southwards, and it seems to be in consequence of this that there is so considerable an exposure of the purple strata in the Llanbedr Farm Dingle.

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[1] W. W. Watts, Proc. Geol. Assoc., 1898, p. 399.

[2] "Geology of Rhyl," etc., p. 27.

Thence to the south end of the Vale we get repeated exposures of the purple strata, and no positive proof of their being anywhere wholly overlapped. Even here, however, there would have been no reason to doubt the existence of a great unconformity, for I noticed that the lower beds of the Trias, in a little escarpment at Garthgynan, contained bands made up apparently of the resorted material of the purple beds with what seemed to be small fragments of Silurian shale. The occurrence of such fragments would at once prove that the Trias overlapped the whole of the Carboniferous system, and would demonstrate the existence of a pre-Triassic syncline, but I was unable to determine them with certainty.

At the extreme southern end of the Vale the synclinal arrangement of the Carboniferous strata is fully revealed. The limestone dipping north-west at Tyn-y-berllan swings round to an easterly dip near Bryn-ffynnon, and in the trough thus formed encloses a small thickness of the purple beds. The Trias comes on close by in the line of the syncline, but appears to be nearly horizontal, while the Carboniferous rocks are more or less tilted. The same remark holds good of the two formations east of Llanfair Dyffryn Clwyd, but the observations are too scanty to be conclusive.

More importance attaches to the relations of the Trias to the limestone along the flanks of the hills west of Llanfair, for in following the base of the Trias along these hills we recede from the axis of the syncline, and at the same time find the Trias creeping across the edges of zone after zone of the limestone, until near Ruthin half that formation has been overlapped. This overlap shows that, whatever synclinal structure the New Red Sandstone may possess, there was a still more pronounced syncline in the Carboniferous rocks, and that it coincided with the existing syncline of the Vale of Clwyd. Between Ruthin and Denbigh the Trias is believed to rest generally on the limestone, but in four places the purple beds peep out between the two. At Llanfwrog they are thrown against the northern termination of the Coed Marchon limestone-range by an east-and-west fault, which is possibly of pre-Triassic age. At Bachymbyd they come out again for a short distance, and with the limestone below them and the Trias above are thrown against Silurian rocks by the Llanrhaiadr fault. The Trias, however, extends to no great depth near the fault, for the stream at Llanrhaiadr, below the waterfall caused by the fault, has cut down to the purple beds, giving the third of the four exposures referred to. The fourth exposure occurs at Pont Ystrad, and occupies exactly the same position relatively to the Denbigh fault as the Bachymbyd exposure occupies to the Llanrhaiadr fault.

Lastly, we have the large area of purple sandstones and shales which were found by Mr. Tiddeman to extend out into the Vale as far as St. Asaph.[1] There, again, the purple beds survived pre-Triassic denudation in considerable thickness.

From this rapid traverse of the sections along the base of the

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[1] "Geology of Rhyl," etc., p. 25.

Trias we see at once that it is quite as unconformable to the Carboniferous rocks in the Vale of Clwyd as it is everywhere else. It certainly overlaps much of the limestone in places, and it certainly reposes upon strata some hundreds of feet above the top of that formation elsewhere. We see further that the greatest thickness of Carboniferous rocks lies in the synclinal trough under the Trias, and that along the margin of the Vale the purple beds are usually on the point of being overlapped. These facts can only be explained on the supposition that the Carboniferous rocks were bent into a syncline, and preserved from denudation thereby, in pre-Triassic times. From the intimate connection between the syncline and the faulting it would seem almost certain that the latter also must have been partly pre-Triassic, and that the post-Triassic disturbances only instituted fresh movements along old lines.

In this, as in other respects, the Vale of Clwyd repeats on a small scale the features of the Vale of Eden. Mr. Goodchild, writing on this subject in 1897,[1] states of the Vale of Eden that "there can be no doubt that, so far as the faults are concerned, they acted as planes of weakness again and again during several geological epochs. Some, probably the majority, are certainly of pre-Carboniferous age; but it can easily be shown that, once a fault has arisen, newer rocks at first deposited continuously across its outcrop, have been dislocated over the older fractures, sometimes in directions of movement the opposite of the original." In the same chapter he informs us that post-Carboniferous (pre-Permo-Triassic) faults followed the direction of pre-Carboniferous line of fracture, and that "the differential movements accompanying the upheaval [of the Permo-Triassic strata] were locally repeated yet again over the older lines of fault."

The overlap of the Carboniferous by the Triassic rocks gives the best proof I know of the pre-Triassic movements in the Vale of Clwyd, but I may add that a strong impression was left in my mind after seeing all the sections that the fracturing and displacement of the Trias was on a small scale compared with that which threw the Carboniferous in a fragmentary condition against the foot of the Silurian ridge.

With the great pre-Carboniferous movements of North Wales the Vale seems to have no connection whatever. The Upper Silurian strata were bent into a multitude of small folds, roughly cleaved, and subjected to vast denudation before the Carboniferous epoch commenced. It is true that they assume a broad synclinal arrangement between the Dee and the Conway, but, as pointed out by Ramsay, the synclinal axis does not coincide with the Vale of Clwyd, but lies considerably to the west of it.[2] The dip of the Carboniferous Limestone, moreover, both in East Flintshire and Denbighshire, is sufficient to carry it clear of the tops of the Silurian hills wherever the two formations are not faulted together, nor in the rocks themselves is there any indication of the immediate neighbourhood of a shore-line, or of a land-barrier having separated the Flintshire from the Denbighshire areas. Had such a feature as the Vale existed when the Carboniferous epoch commenced, the Basement Conglomerates of that formation would have certainly revealed it. As a fact, they are almost wholly absent along the Flintshire escarpment and along the east side of the Vale of Clwyd, and though they appear in an attenuated form at the north-east end of the Vale and extend continuously from the south-west end near Llanelidan past Denbigh and Abergele to Colwyn Bay,[1] they always tend to develop in thickness and in coarseness of conglomerate northwards and westwards, but neither in the Vale, nor along it, but away from it.

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[1] Geological Survey Memoir on Appleby, etc., p. 33.

[2] Memoirs of the Geological Survey, vol. iii (1881), p. 307.

The history of the Vale of Clwyd commenced, therefore, by the formation of a deep faulted syncline during the great disturbances which affected all the British area at the close of the Carboniferous epoch. During the Continental period to which those disturbances led, the Carboniferous rocks were deeply denuded from the anticlinal regions, but preserved in the synclinal folds. Upon the faulted and tilted remnant thus left in the Vale of Clwyd, the New Red Sandstone was overspread, probably overlapping it, though how far no evidence has been left to show. Long subsequently, not improbably in Miocene times, a new and widespread disturbance caused renewal of movement along the old fractures, and threw the New Red Sandstone also into the form of a faulted trough, at the same time that it must have emphasized the already existing syncline in the underlying Carboniferous strata.

REVIEWS.

I.—WACHSMUTH AND SPRINGER'S MONOGRAPH ON CRINOIDS.[2]

SIXTH AND FINAL NOTICE.

WE have now considered the Introductory and Morphological Parts of this great work. But these, though of more general interest, serve but as foundation for the main structure, the systematic account of the North American Camerate crinoids. This Systematic Part occupies 695 of the large quarto pages, a bulk that may astonish those who regard the Crinoidea as quite a small class. Really the system of the crinoids is assuming considerable proportions; he who would master it must know the literary history of nearly 450 names, and must be prepared to classify some 250 valid genera. Moreover, the number of known genera and species increases with alarming rapidity; 13 genera and 250 species were described as new during 1896 and 1897.

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[1] Quart. Journ. Geol. Soc., vol. xxxv, p. 268 (1879).

[2] The North American Crinoidea Camerata. By C. Wachsmuth and F. Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897.) For First, Second, Third, Fourth, and Fifth Notices, see GEOL. MAG. for June, July, September, and November, 1898, and January, 1899.

The value of a work like the present depends less on the number of new forms it makes known, than on the care with which it revises previous descriptions, confirms or rejects previous proposals, and summarizes with lucidity the valid residue. It must have been a disappointment more bitter to the authors than it will be to their readers, when they found that they could not make a monograph even of so restricted a portion of the field either complete or authoritative. Long years of labour in field and study, the accumulation of literature in a Western town, the unwearying collection and comparison of specimens new and old, all were deprived of their full and deserved effect when it was found impossible to examine a number of type-specimens, and when, during the very years that the work was printing, less careful or less learned writers were grinding out descriptions of species with a truly indecent haste. It was found impracticable to alter the manuscript to any great extent after it was first sent to the printers on September 1st, 1894. Consequently it is very important that all species published elsewhere between that date and May, 1897, should undergo revision and comparison with species first described in the Monograph. Till this is done and till all type-specimens have been compared, we cannot look for a standard list of North American Camerate Crinoids.

The Systematic Part opens with a section headed 'Classification.' With the broad lines of the classification of Crinoidea here proposed I have dealt elsewhere,[1] while previous chapters of the present review have touched on minor details connected with the classification of the Inadunata and Flexibilia. On the present occasion attention may be confined to the treatment of the Camerata.

The Camerata are defined (p. 169) as "Crinoids in which the lower brachials take part in the dorsal cup. All plates of the calyx united by close suture. Mouth and food-grooves closed. The top joint the youngest in the stem." If such genera as *Actinocrinus*, *Coccocrinus*, *Idiocrinus*, *Reteocrinus*, and *Enallocrinus* are all to be included in one Order, then one could hardly have a longer diagnosis; even as it stands, it is doubtful whether the criteria can be applied throughout. For instance, it is only by stretching a point that any brachials can be said to take part in the cup of *Coccocrinus*; one would not naturally suppose that the minute and irregular interbrachials of Reteocrinidæ were united by close suture; it is doubtful whether the food-grooves of the tegmen (which are what the authors mean) were closed in *Idiocrinus*; as for the last of the characters, it may be constant, but it is said also to characterize all Inadunata.

Broadly speaking, no doubt, the essential features of the so-called Camerata are the incorporation of brachials in the cup by means of interbrachials and the rigid fixation of all calycal elements. But it is admitted (p. 154) that these characters are essentially modifications imposed on an Inadunate type, and it must further be conceded that they arose in different branches at different times. Whereas the Melocrinidæ (*sensu* W. & Sp.) existed already in Lower Ordovician times, the rise of the Platycrinidæ is traceable in the Middle and Upper Silurian, at which time also the Crotalocrinidæ, which "represent a different degree of departure from the Inadunate plan" (p. 164), first made their appearance. The question that confronts us here, as in other Classes of living beings, is whether similarity of modification is to have more classificatory weight than admitted differences of descent. From the day when the cetaceans were first separated from the fish, there has been an increasing tendency to answer this question in the negative, no matter when or where it comes up for solution.

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[1] "Wachsmuth and Springer's Classification of Crinoids": *Natural Science*, xii, pp. 337–345; May, 1898.

Even Wachsmuth and Springer admit the heterogeneous nature of their Camerata, and divide the Order into: a Typical Section, in which the lower brachials and interradials form an important part of the dorsal cup; and a Non-typical Section, in which the brachials retain the form and small size of arm-plates, and the interradials are almost exclusively confined to the tegmen. Had the 'Non-typical' genera arisen first, and had their non-typical nature been due merely to arrest of development, there might be some reason or some advantage in associating them with the 'typicals.' But the fact to be emphasized is that they have no connection whatever with the rest of the Camerata. Moreover, they are themselves a heterogeneous lot, for the Crotalocrinidæ admittedly have more to do with the Dicyclic Inadunata (more particularly, the Cyathocrinidæ) than with the Monocyclic *Platycrinus* and its allies. If these statements represent a general opinion, there seems no reason why the Crotalocrinidæ should not remain in the Cyathocrinoid division of Dicyclic Inadunata, and why the rest of the 'Non-typical Camerata' should not form an independent Order (of Monocyclica). For such an Order the name Adunata is elsewhere proposed.[1]

As for the Typical Camerata, they do indeed appear to form a fairly homogeneous group; but the appearance may be deceptive. Wachsmuth and Springer do not attempt to name any subordinal divisions, but in their analysis (p. 170) they group the families under two main heads: A. Interradials ill defined; B. Interradials well defined. The former contains both monocyclic and dicyclic forms, all of which are lumped in one family—Reteocrinidæ. Group B. undergoes further division into: 1. Monocyclic (Thysanocrinidæ, Rhodocrinidæ); 2. Dicyclic (Melocrinidæ, Calyptocrinidæ, Batocrinidæ, Actinocrinidæ). Surely it is plain that the "unique and remarkable" structure of the interbrachial areas of the Reteocrinidæ represents a primitive stage in the evolution of interbrachials. Their irregular size is supposed by the authors to be due to "the intercalation of supplementary pieces" around the larger plates which "represent" "the first and second row of interbrachials in the Actinocrinidæ" (p. 184). This implies that the structure of the interradii of the Carboniferous family Actinocrinidæ is more primitive than that of the Ordovician Reteocrinidæ—a quaint paradox. On the contrary the Reteocrinid structure follows the arrangement usual in primitive many-plated areas just undergoing evolution into few-plated areas; a similar arrangement is seen in *Eocystis*, Walcott, *Deutocystis*, Barrande, in *Diabolocrinus* of the Trenton Limestone, and in the carapace of *Glyptodon*. The outward appearance of these areas may be striking, but the structure is the reverse of fundamental, and examination of the three genera referred to the family fails to show more important points of resemblance. It is not merely simpler, but more likely to bring out affinities, if we run the line between Monocyclica and Dicyclica right away through the typical Camerata. We must in fact regard the two divisions as exhibiting homoplastic modifications of distinct Inadunate stocks.

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[1] F. A. Bather, "A Phylogenetic Classification of the Pelmatozoa": *Rep. Brit. Assoc.* for 1898, pp. 916–923; 1899.

The genera are arranged in families as follows:—

1. Reteocrinidæ: *Reteocrinus, Xenocrinus, Tanaocrinus.*
2. Thysanocrinidæ: *Ptychocrinus, Thysanocrinus, Hyptiocrinus, Idiocrinus, Lampterocrinus, Siphonocrinus.*
3. Rhodocrinidæ: *Rhaphanocrinus, Archæocrinus, Diabolocrinus, Rhodocrinus, Gilbertsocrinus, Thylacocrinus, Lyriocrinus, Anthemocrinus, Rhipidocrinus, Diamenocrinus.*
4. Melocrinidæ: i. Melocrinites — *Glyptocrinus, Periglyptocrinus, Stelidiocrinus, Mariacrinus, Scyphocrinus, Melocrinus, Macrostylocrinus.*
    ii. Dolatocrinites — *Technocrinus, Corymbocrinus, Patellıocrinus, Allocrinus, Centrocrinus, Dolatocrinus, Stereocrinus, Hadrocrinus.*
5. Calyptocrinidæ: *Eucalyptocrinus, Callicrinus.*
6. Batocrinidæ: i. Batocrinites — *Batocrinus, Eretmocrinus, Alloprosallocrinus, Lobocrinus, Macrocrinus, Eutrochocrinus, Dizygocrinus, Barrandeocrinus, Aorocrinus, Dorycrinus, Agaricocrinus, Acacocrinus, Habrocrinus, Desmidocrinus, Compsocrinus.*
    ii. Periechocrinites—*Periechocrinus, Megistocrinus, Gennæocrinus, Abacocrinus.*
7. Actinocrinidæ: *Actinocrinus, Steganocrinus, Amphoracrinus, Cactocrinus, Teleiocrinus, Physetocrinus, Strotocrinus.*

For practical purposes, and with the help of the keys prefixed to each family, this grouping does well enough, and in the main it follows the broad lines of descent. At any rate it is an improvement on previous schemes. But it is the ill fate of such improvements always to disclose avenues of further progress. A few such may be alluded to.

The family Reteocrinidæ may be retained for *Reteocrinus*, but *Xenocrinus* and *Tanaocrinus* are more suitably placed at the base of the assemblage called Batocrinidæ by our authors.

The Thysanocrinidæ, to which Jaekel's *Orthocrinus* must now be added, should be relieved of *Idiocrinus*. This has not a tegmen of true Camerate type; its arms, so far as known, are not pinnulate; and its dorsal cup scarcely differs from that of *Anisocrinus*, which is a Taxocrinid. To judge from the published descriptions, it might well form a family of Flexibilia Impinnata, but is a primitive genus not far removed from Inadunata. It would also conduce to clearness to separate *Lampterocrinus* and *Siphonocrinus* as a family Lampterocrinidæ.

The Rhodocrinidæ present no difficulty, and complete the series of Dicyclic Camerata. All the rest are Monocyclic.

The Melocrinidæ of Wachsmuth and Springer comprise genera of such diverse nature that it is straining the conception of a family (as now recognized) to keep all under one name. At the same time the relations of *Eucalyptocrinus* and *Callicrinus* to some of them are confessedly intimate. On the other hand the subdivision into Melocrinites and Dolatocrinites is not regarded as satisfactory, even by its proposers. Similar criticism applies to the Batocrinidæ and its subdivisions, and to the Actinocrinidæ. None the less the reality of these large divisions should not be overlooked. I propose, therefore, to divide the Dicyclica Camerata into three Suborders—Melocrinoidea, Batocrinoidea, Actinocrinoidea—and to subdivide each of these into more limited families. The details will be given more fully elsewhere,[1] but it may be of interest to print a table for comparison. The genera are arranged in their supposed evolutionary order.

MELOCRINOIDEA.

1. Glyptocrinidæ: *Glyptocrinus, Schizocrinus, Periglyptocrinus.*
2. Melocrinidæ: *Scyphocrinus, Mariacrinus, Melocrinus, Ctenocrinus.*
3. Patelliocrinidæ: *Stelidiocrinus. Macrostylocrinus, Allocrinus, Patelliocrinus, Briarocrinus, Centriocrinus.*
4. Clonocrinidæ: *Clonocrinus* (= *Corymbocr.*), *Polypeltes, Trybliocrinus* (= *Spyridiocr.*), *Technocrinus.*
5. Eucalyptocrinidæ: *Callicrinus, Eucalyptocrinus.*
6. Dolatocrinidæ: *Dolatocrinus, Stereocrinus, Hadrocrinus.*

BATOCRINOIDEA.

1. Tanaocrinidæ: *Tanaocrinus.*
2. Xenocrinidæ: *Xenocrinus, Compsocrinus, Abacocrinus.*
3. Carpocrinidæ: *Acacocrinus, Desmidocrinus, Macarocrinus, Carpocrinus.*
4. Barrandeocrinidæ: *Barrandeocrinus.*
5. Cœlocrinidæ: *Cœlocrinus* (= *Aorocr.*), *Dorycrinus, Agaricocrinus.*
6. Batocrinidæ: *Batocrinus, Eretmocrinus, Alloprosallocrinus, Eutrochocrinus, Dizygocrinus, Hyperocrinus* (= *Lobocr.*), *Macrocrinus.*
7. Periechocrinidæ: *Periechocrinus, Megistocrinus, Gennæocrinus.*

ACTINOCRINOIDEA.

1. Actinocrinidæ: *Actinocrinus, Steganocrinus, Cactocrinus, Teleiocrinus, Physetocrinus, Strotocrinus.*
2. Amphoracrinidæ: *Amphoracrinus.*

The possible non-acceptance of certain details in Wachsmuth and Springer's classification cannot affect the high value of the Monograph as a storehouse of facts both new and old, while the Index and numerous tables enable one to track the contents with ease. The following new genera are described:—

Aulocrinus (p. 138, and pl. vii, fig. 9) is an ally of *Scaphiocrinus*, characterized by a forked anal tube. May not this be a persistent abnormality due to the presence of a commensal in the tube?

Tanaocrinus (p. 185), Ordovician, referred to Reteocrinidæ, but is monocyclic and apparently a Batocrinoid; in structure and in time it is well fitted to be taken as an ancestor of the Carpocrinidæ.

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[1] See "A Phylogenetic Classification of the Pelmatozoa," loc. cit.

Diabolocrinus (p. 249), Ordovician, a Rhodocrinid in which the interbrachials consist of larger plates surrounded by smaller ones, the anus is at the end of a tube, and the arms bear ramules.

Periglyptocrinus (p. 277), Ordovician, a Glyptocrinid with large basals and biserial arms.

Eutrochocrinus (p. 408), with genotype *Batocrinus Christyi*, *Dizygocrinus* (p. 413), with genotype *B. indianensis*, *Lobocrinus* (p. 434), with genotype *B. Nashvillæ*, and *Macrocrinus* (p. 446), with genotype *B. Konincki*, are closely allied genera of Batocrinidæ (*s.str.*) and all Lower Carboniferous.

Aorocrinus (p. 470) is a Devonian and Carboniferous predecessor of *Dorycrinus* and *Agaricocrinus*; the genotype is *D. immaturus*.

Acacocrinus (p. 515) is a Silurian subgenus of *Carpocrinus*, for the reception of *A. Elrodi* and *A. americanus*, but is worthy of generic rank.

Cactocrinus (p. 600), with genotype *Actinocrinus proboscidialis*, is separated from *Actinocrinus* because the arm-rami are given off in a continuous circlet around the theca, clearly separating the tegmen from the cup: the name is due to the spines on tegmen and arms; those on the pinnules imbricate over those of adjacent pinnules.

Camptocrinus (p. 779) differs from *Dichocrinus*, under which it is placed subgenerically, in the structure of the stem, which is modified like that of Hall's *Myelodactylus* and Salter's *Herpetocrinus*. *Camptocrinus* is in the Keokuk and Kaskaskia groups. Similarly modified stems were possessed by Poteriocrinidæ of Kaskaskia age. There is therefore room for doubt whether the European *Herpetocrinus* really is congeneric with the American *Myelodactylus*. No detailed account of the stem of *Camptocrinus* is given, so that one cannot ascertain to what extent it agrees with that of *Herpetocrinus*.

These genera, as well as the new species described, appear to have been established with care, and may safely be accepted. The principles guiding the authors are thoroughly in accordance with the most approved modern views. They recognize the corollary of the theory of descent, namely, that the taxonomic value of a character is in proportion to its persistence and not to its physiological importance (p. 153). Still no single character is absolutely constant, "and the larger our collections the less persistent and fixed will we find the separate characters. But if we are reasonably happy in our identifications, we may expect to find greater reliance to be put upon the correlation of characters, so that while one or more of them will show a tendency to departure, the sum of all will exhibit a predominance which will hold the form in question within the given group." Characters cannot be sorted out as of 'family,' 'generic,' or 'specific' importance, but the value or rank of a character "is proportional to the extent to which it tends to combine subordinate groups." Later on (pp. 155, 156) the difficulties attaching to the separation of species are discussed, and the necessity for appreciating stages of growth, limits of individual variation, and abnormalities is emphasized. Valuable illustrations of these difficulties will be found under *Teleiocrinus umbrosus* (p. 629) and under *Platycrinus* (pp. 652, 680, 681). The modifications due to individual growth in the latter genus are very striking, and unless they are taken into consideration the describing of species amounts to little more than description of individual specimens. The authors base their observations largely on over a thousand specimens of *P. Huntsvillæ* collected by them, and varying from 9 mm. to 50 mm. in length of crown. So important is work of this nature, that we should have been glad of a far more detailed account and more even than the eight figures which are given of this species.

Towards the governing problems of evolution and phylogeny, our authors adopt a very cautious attitude, defended in some admirable passages (pp. 166–169). "It is," they consider, "impossible to tell, except perhaps in a very general way, which one of a number of variations marked the line of succession; or in other words which was for the time being the racial characteristic carrying all others along with it, even though many of them may seem more important." The metaphor is not commendable: at least it seems to me that the racial characteristic is usually some feature that escapes modification just because it is functionally unimportant for the time being; it follows other changes, itself unchanged.

The difficulty of deciding which are the important structures is well illustrated by *Lyriocrinus*. In the two species of this there often occur variations in "characters which have always been regarded as of the utmost significance for distinguishing families and genera," namely, the relation of interradials and basals, and the presence of an anal plate (p. 262).

Such considerations have led Messrs. Wachsmuth and Springer to shun "the primrose path of dalliance" with evolution, which they fear leads only to "the everlasting bonfire" of genealogical trees. With the modesty that comes of true learning they content themselves "with giving the general facts which [their] investigations seem to pretty well establish, and such interpretation of them as appears reasonably consistent therewith" (p. 166).

The absurd guesses that one so often sees put forward as sober accounts of phylogeny are enough to compel sympathy with the preceding remarks. But of all virtues prudence is the most uninteresting, and an author should at least have the courage of his convictions. The downfall of so many phylogenetic erections is due to the fact that they are built with their foundations in the air. It is possible, in many cases, to trace the relation of species to species, or the evolution of one genus from another: such statements often attain almost the dignity of facts, and can be checked by stratigraphy and palæo-geography. Let us begin with these, and, when the relations of genera are fairly settled, let us proceed to those of families. Thus the Orders will take shape before us, and we shall have a truer conception of what their ancestral forms were. Then we can think about the relations of Crinoidea to Cystidea and of Asteroidea to Echinoidea. And some day we may even have a right to speculate on the connection between Echinoderma and Prochordata.

Now my criticism of this Monograph is that it does not fairly represent the beliefs of its authors in these matters. They say, it is true, "We have arranged our descriptions so as to place species which are most closely related next to each other" (p. 156). But if they have done this, it has been in a very obscure fashion; and the same principle is far from being extended to genera. The species of *Platycrinus* have been arranged in groups around certain typical species: without some such device the crowd of them would be unmanageable. But one would have liked some key to the arrangement, and an extension of the method to other genera. Consider the species of *Batocrinus*! The account begins with two allied forms from the Warsaw Limestone[1]; then come four, possibly allied to one another but not to the preceding, from the Lower Burlington of Iowa; then species from the base of the Lower Burlington of Missouri, one of them approaching *Dizygocrinus*, another near *Lobocrinus* and *Eretmocrinus*; next come two interrelated species from the Kinderhook, from which we jump to quite a different form in the Upper Burlington, then down again to its ally in the Lower Burlington; then some species, the mutual relations of which are not stated, from the Keokuk, and so back to Upper Burlington. There may be a reason for this erratic promenade; but if so, it should be stated. Again, under *Teleiocrinus*, *T. adolescens*, though said to be the species most closely allied to *Cactocrinus*, is dealt with furthest away from that genus. One begins to long for the simplicity of the alphabet. So too with the genera. *Aorocrinus* is described after *Dorycrinus*, though it is admitted to be its ancestor. Similarly *Physetocrinus* is held to give rise to *Strotocrinus*, and *Cactocrinus* to *Teleiocrinus*; but the order of treatment is—*Physetocrinus, Cactocrinus, Teleiocrinus, Strotocrinus.*

After the richly deserved blame which is awarded to other writers for not marking the relations of their species, one would at least expect some words of comparison to accompany each description. The frequent absence of this would not so much matter, did the authors condescend to follow the example of Linnæus and give a diagnosis of each genus and species. Instead, one has often to wade through a page or more of description, comparing it word by word with other descriptions, in order to find out the truly diagnostic characters. This is a fault so common that it may seem pedantic to notice it. So much the worse!

It must be admitted that, so far as genera are concerned, the authors have done their duty in the way of providing analytic keys. As these will probably be referred to by many students, it may be as well to point out some inconsistencies. In the analysis (p. 188) *Ptychocrinus* is said to have 10 arms; the description (p. 197) says "10 to 12"; but according to the descriptions and figures of species the rami are at least 20. In the analysis of Rhodocrinidæ (p. 215) it should be noted that *Gilbertsocrinus* has no anals, and that *Lyriocrinus* may have an anal, a correction that makes the divisions

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[1] Readers of the GEOLOGICAL MAGAZINE scarcely need to be reminded that the order of the stratigraphic groups, from above downwards, is: Kaskaskia, St. Louis, Warsaw, Keokuk, Burlington, Kinderhook.

A and B of small practical use. Here also the statement "no interdistichals" is not applicable to all species of *Rhodocrinus*. In the key to Melocrinidæ we read, "C. Basals large"; but lower down *Dolatocrinus* is said to have "basals small, interbrachials few." The latter statement further conflicts with the "Interbrachials rather numerous" of p. 310. The analysis of Batocrinidæ (p. 361) obviously has *Macrocrinus* in the wrong place, since it has "Interbrachials in contact with interambulacrals at anal side only." *Eutrochocrinus* is here said to have "respiratory pores twenty," but this is not mentioned in the generic and specific descriptions. The pores of *Dizygocrinus* are said to be "not visible," but later on are described as "small."

A few other slips of like nature may be noted. On p. 205, under *Idiocrinus ventricosus*, is written "cup obtusely pyramidal"; for 'cup' read 'tegmen.' In the description of *Lampterocrinus* (p. 207) the brachials and covering-pieces are said to form a rigid tube, from which small arms are given off alternately at intervals. This statement was put forward as a hypothesis in Wachsmuth and Springer's "Revision of the Palæocrinoidea, Part II"; it does not appear to have received definite confirmation (cf. p. 209). In the description of *Siphonocrinus* (p. 210) the words "Basals five" have been omitted after "Infrabasals five." Under *Rhaphanocrinus* (p. 259) the arms are said to be "not bifurcating"; they really fork once or twice, and probably what is meant is the free portion of the arm. The basals of this genus are described as hexagonal, but they do not appear to differ from those of *Archæocrinus*, which are called heptagonal. The basals of *Lyriocrinus* are certainly heptagonal, not "hexagonal" (p. 261). *Batocrinus* (p. 366) is said to have "Arms 20 to 26," but in *B. irregularis*, *B. mundulus*, and *B. cantonensis* the rami are only 18. The horizon and locality ascribed to *B. turbinatus* and its var. *elegans* are incorrect. Hall said Burlington Limestone, Burlington, and Miller and Gurley's type of the synonym *B. lætus* came from Sedalia, Missouri. Keyes' reference in the Missouri Report was possibly copied from the proof-sheets of this Monograph, of which he was one of the artists. *Cordylocrinus plumosus* comes from Upper, not "Lower" Helderberg (p. 737). The footnote on p. 284 apparently should refer to *Mariacrinus ramosus* only, not to *M. plumosus*. *Hyptiocrinus typus*, *Idiocrinus ventricosus*, *Eucalyptocrinus Lindahli*, *Melocrinus oblongus*, and *M. Roemeri* are not new species, but were described in a preliminary notice published in the *American Geologist* for September, 1892. *Cactocrinus obesus* is not "Keyes (MS.)," but was published in *Missouri Geol. Survey*, vol. iv, part 1, p. 187, pl. xxiv, fig. 4. If that volume was issued in 1894, as stated on its title-page, the reference might have been entered; at any rate there is only one holotype, and that is not "in the collection of Wachsmuth and Springer" (p. 614).

Finally, some questions of nomenclature need attention. The genera *Dimerocrinus*, *Glyptaster*, *Thysanocrinus*, and *Eucrinus* are reduced to one, and for that the name *Thysanocrinus* is selected.

I accept the fact, but not the name. *Dimerocrinus* has sixteen years priority, and, however bad Phillips' description[1] and figures may have been, there has never been the smallest doubt as to the identity of the species. The genus must be called '*Dimerocrinus*' and the family 'Dimerocrinidæ.'

Hyptiocrinus and *Idiocrinus* are recognized as identical with the *Cyphocrinus* and *Gazacrinus* of Miller, and the type-species also are the same. Wachsmuth and Springer's names were first published in the *American Geologist* for September, 1892, and Miller's names were published in Advance Sheets from the 18th Report of the Geological Survey of Indiana. The date of these Advance Sheets, which I know were obtainable through trade channels, is here given as "October 26, 1892," and we are left to infer that the *American Geologist* was issued on September 1, or soon after. Now Miller's Advance Sheets were dated "September, 1892," and in the Second Appendix to his "North American Geology and Palæontology," issued October, 1897, Miller cited four witnesses to prove that his copies were distributed by the Survey on September 1. This might not have given Miller priority, were it not for the fact that the issue of the September number of the *American Geologist* was delayed. This I had from Miller himself in a letter dated March 14, 1894, and I confirmed it by reference to the date on which the number was received at the British Museum, namely, September 27, the usual date being about the 15th of the month of issue. So far Miller's statements have not been challenged; his descriptions are perfectly intelligible and accompanied by figures, which Wachsmuth and Springer's were without. The names *Cyphocrinus Gorbyi* and *Gazacrinus inornatus* must therefore take precedence of *Hyptiocrinus typus* and *Idiocrinus elongatus* respectively. In this connection it should be pointed out that though our authors set their imprimatur on one of Miller's figures of *C. Gorbyi* by reproducing it without comment, they have not modified their descriptions in accordance with it. Therefore their descriptions cannot supersede those by Miller, which appear to be quite accurate. Similar criticism applies in less degree to the account of *Idiocrinus*.

There is no obvious reason why Miller's trivial name '*lyonanus*' (December, 1893) should not be preferred for "*Gilbertsocrinus dispansus* (nov. sp.)," of which it is made a synonym. Miller's type-specimen has six appendages, five paired and one single, but no allusion is made to this in the Monograph.

Wachsmuth and Springer's principles of nomenclature are nowhere more difficult to follow than in their treatment of certain subgeneric names adopted by Meek and Worthen. In 1865 those writers proposed *Uperocrinus* (which we should nowadays write *Hyperocrinus*) as a subgenus of *Actinocrinus*, with type-species *A. piriformis*. This and a few allied species are now formed into "*Lobocrinus* (nov. gen.)," with genotype *Batocrinus Nashvillæ*. Such action at least demands the justification which is nowhere attempted. In 1865 Meek and Worthen proposed another subgenus under the name *Sphærocrinus*, which, being preoccupied, was changed into *Cœlocrinus* on January 1, 1866. The genotype was *A. concavus*, a fairly characteristic species of what Wachsmuth and Springer now wish to call "*Aorocrinus* (nov. gen.)." The name *Cœlocrinus* does not conflict with *Cœliocrinus*, White, 1863, and it preceded Salter's *Cœlocrinus*[1] by some months; it must be adopted. In 1881 Wachsmuth and Springer proposed a subgenus of *Macrostylocrinus* under the name *Centrocrinus*. They were aware that this name had been proposed by T. and T. Austin, but say that "the name has never been accepted by any writer, nor was it applied to any particular species by Austin himself." It was, however, accepted by Meek and Worthen in 1866 (*Geol. Surv. Illinois*, ii, p. 172), and defined with *Platycrinus gigas* as type. Since, therefore, *Centrocrinus*, W. & Sp., cannot stand, I have proposed[2] to change it to CENTRIOCRINUS, from *κέντριον*, 'a sting,' in allusion to the sharp spines in the type-species, *C. pentaspinus*.

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[1] Wachsmuth and Springer are wrong in saying the species were "not described" (p. 191).

Carpocrinus, Müller,[3] cannot be replaced by *Habrocrinus*, Angelin, 1878, on the ground of a single error in Müller's diagnosis; the genotype '*Actinocrinus simplex*' of Phillips has always been readily recognized.

There is far better reason to reject *Marsupiocrinites*, Phillips, 1839, previously used by De Blainville 1830;[4] it would be replaced by *Cupellæcrinus* (or *Cypellocrinus*, as we should now write it), Shumard ex Troost, 1866.

The genus *Trybliocrinus*, Geinitz, 1867, is alluded to on p. 216. There can be no doubt that this is the same as *Spyridiocrinus*, Oehlert, 1891. It may also be pointed out that *Clonocrinus*, Quenstedt, 1876, with genotype *Eucalyptocrinus polydactylus*, M'Coy (non *Clonocrinus*, Oehlert, 1879), takes precedence of *Corymbocrinus*, Angelin, 1878.

But the problems of nomenclature would keep us a thousand and one nights over this Monograph, of which it is now time to take leave. So full is it of matter and suggestion, that one might spend years in its study. This Review of it, though long, has been inadequate; but the criticism at least has been carefully considered and outspoken. Differences of opinion cannot possibly diminish the great and permanent value of the book, and everyone must hope that Mr. Frank Springer may be able before long to continue the work in which he has for many years been the colleague of Charles Wachsmuth.

These volumes are dedicated to the memory of Louis Agassiz, and it is due to the generosity of Alexander Agassiz that they appear as a Memoir of the Museum of Comparative Zoology at Harvard College. They are worthy of this intimate association with a great name.

F. A. BATHER.

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[1] Appendix to A. C. Ramsay's "Geology of North Wales," First Edition, pp. 283, 284.

[2] *Rep. Brit. Assoc.* for 1898, p. 922; 1899.

[3] Ber. Akad. Wiss. Berlin for 1840, pp. 88–106; [July ?] 1840. *Carpocrinus* on p. 92.

[4] See F. A. Bather, "Note on *Marsupites testudinarius*": Quart. Journ. Geol. Soc., xlv, pp. 172–174; Feb. 1889.

II.—Manual of Determinative Mineralogy, with an Introduction on Blowpipe Analysis. By George J. Brush. Revised and enlarged, with entirely new tables for the identification of minerals, by Samuel L. Penfield. 15th edition. Large 8vo; pp. x, 264, 58 tables, 375 figures. (New York and London, 1898.)

THE publication in 1896, under the editorship of Professor Penfield, of a *semi*-revised version of Brush's well-known work on the chemical determination of minerals seemed at the time a matter of doubtful policy, for would-be purchasers might well have felt inclined to wait for the next edition, containing, according to the editor's promise, a complete revision of the tables for the identification of minerals and an additional chapter on crystallography and the physical properties of minerals. As it appears, they would not have been compelled to wait long. In the present work Professor Penfield has fully redeemed his promise, and has very successfully completed the work of revision which he had undertaken.

The introductory chapters remain practically the same as in the edition of 1896. The most important changes, it will be remembered, were made in the chapter on the chemical reactions of the elements. This was extended from the fourteen pages of the older editions to ninety-four, and in its new form was eminently suggestive and instructive. The treatment was not confined to the blowpipe characters, but tests in the wet way were also given, especially in the case of elements such as those of the rare earths, which cannot be satisfactorily identified by the blowpipe alone. The minute details given in the chapter as to manipulation and the precautions necessary to ensure success should be of great service to the student in preventing him from drawing false conclusions from his experiments.

The additional chapter in the present edition on the physical properties of minerals is mainly occupied with the elementary principles of crystallography. The various types of crystals are grouped under the now accepted thirty-two classes according to the degree of symmetry they exhibit. The Millerian system of notation for the faces is explained, but no attempt is made to demonstrate the mathematical relations connecting the indices with the interfacial angles, etc. The object, in fact, has been to present the subject in as simple (and yet an adequate) a way as possible, so that the student, with the help of models, may become familiar with the more important forms presented by well-known minerals, and may thus be assisted in their identification.

The subject of mineralogy comprises so many branches of chemistry and physics that the author of a text-book, through want of space, has generally to sacrifice one part of his subject for the sake of fuller treatment of others. In the present work Professor Penfield gives us a very useful and instructive chapter on crystallography, but from limited space draws the line at the optical properties of minerals. For a description of these we are referred to his colleague, Professor E. S. Dana's "Text-book of

Mineralogy," a new edition of which has just appeared. We cannot help feeling some regret that in a work on determinative mineralogy the author has felt compelled to omit even a brief account of one of our most important aids in the identification of minerals. As a manual for the *chemical* determination of minerals, the older editions of Brush's work could be regarded as complete; but with the introduction of a chapter on crystallography in the present edition, the character of the work is so far changed that as a manual of determinative mineralogy it appears incomplete without a chapter on the optical properties of minerals.

The tables for the identification of minerals at the end of the book, originally founded on those of Von Kobell, have been brought up to date and completely rearranged: they are intended to include all well-characterized species at present known. G. T. P.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—January 18, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On a small Section of Felsitic Lavas and Tuffs near Conway (North Wales)." By Frank Rutley, Esq., F.G.S.

The rocks described in this communication were collected in 1877, in series, at short intervals, from a point at the mouth of the River Conway near Bodlondeb. They consist of felsitic lavas and tuffs, sometimes nodular, and generally exhibiting some variety of fluxion-structure, corrugated, or banded. A specimen showing brown bands is compared with one described by Iddings from the Yellowstone Park. What were once possibly red bands are now represented by devitrified brown glass, and the change in colour may have been due to the action of water upon the ferric oxide which originally gave its colour to the glass. Some of the rhyolites are tufaceous, and envelop fragments of rocks, some of which were originally vitreous, others lithoidal. Coarser rhyolitic tuff occurs at the northern end of the series.

2. "The Geology of Southern Morocco and the Atlas Mountains." By the late Joseph Thomson, Esq. (Communicated by the President.)

This paper gives the results of observations made under considerable difficulties during a journey in Morocco in 1888. The tract traversed is roughly triangular, the base being the Atlantic Ocean between Saffi and Agadir, and the apex the district of Demnat on the northern slopes of the Atlas, some sixty miles east of the city of Morocco. This district consists of three main sections: (1) The Coast Lowlands; (2) the Plateau in two chief steps, the northern rising to 2,000 and the southern to 5,000 feet: (3) the Atlas itself, which only begins to be a mountain-chain about thirty miles from the coast, and which ranges first east-by-north and then north-east in its central and loftiest part.

(1) The Lowlands are practically conterminous with the Tertiary deposits, among which apparently Eocene, Miocene, and Pliocene rocks are represented. The last-named consist of shelly sands 200 to 300 feet thick, gradually rising to a height of 700 feet south and east of Saffi. Their surface is often covered with the slaggy tufaceous crust described by Maw. The local presence of this crust and the porous character of the deposit elsewhere have preserved it from denudation, and thus (in the opinion of the author) its surface still presents the appearance of the Tertiary sea-bed on which it was formed. Certain quarry-like pits, one of which contains a pillar of white crystalline calcium carbonate, are supposed to be due to the explosion of steam connected with the existence of hot springs.

(2) The Plateau is underlain by three rock-formations:—(*a*) Metamorphic rocks including clay-slates, which probably underlie the whole Plain of Morocco and rise into a group of rugged hills called the 'Jebêlet,' in contradistinction to the 'Jebel' or Atlas proper. (*b*) The Lower Cretaceous rocks, consisting of red shales and sandstones, the former frequently giving rise to brine springs and containing salt-deposits at Demnat in the Atlas. (*c*) The Upper Cretaceous rocks, chiefly white and cream-coloured limestones, which attain their greatest development on the Plateau.

(3) The Atlas itself is made up for the most part of the same rocks. There is a core of metamorphic rocks, which is better developed and wider at the western end of the range and narrower towards the east. Next comes the great development of the Lower Cretaceous strata, followed by a diminutive representative of the Upper Cretaceous rocks. These rocks are much broken by folding and faulting, and their structure is displayed in several sections taken across the range from Demnat westward. The first signs of glacial action were met with at Titula, consisting of moraine-like heaps of débris; elsewhere, scratched stones were found. The Boulder-deposits described by Maw were not seen either east or west of the locality described by that author; but Maw's original section was not traversed, and the present author does not offer any opinion as to the origin of the beds. Intrusive basalts penetrate the Cretaceous rocks, while porphyrites, diorites, and other igneous rocks pierce the metamorphic rocks of the central core.

II.—February 1, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On Radiolaria in Chert from Chypon's Farm, Mullion District (Cornwall)." By Dr. G. J. Hinde, F.R.S., F.G.S.

This paper describes the discovery of a bed of chert on the mainland, similar to that already described from Mullion Island. It was found in 1877 by Mr. Howard Fox at Chypon's Farm. Although detached blocks had been noticed in the fields, the rock had not been previously observed *in situ*. The chert is interbedded with clay-slates, and it is a dark massive rock much traversed by quartz-veins; in some parts of it the radiolaria are preserved in an unusually perfect condition, showing their latticed structure and spines very distinctly. The radiolaria for the most part are casts only, without any definite bounding-walls, their outlines being indicated by the dark material of the groundmass, while the interior of the test has been infilled with clear silica, sometimes the cryptocrystalline variety, at others fibrous chalcedony. In the forms showing the structural details, these alone have been replaced by the opaque substance, and are thus well defined against the clear silica infilling the test. Eleven species are described, of which ten are new, while one has been previously recognized in the cherts of New South Wales.

2. "Gravel at Moreton-in-the-Marsh (Gloucestershire)." By S. S. Buckman, Esq., F.G.S.

The author describes certain gravels of Triassic débris and flints at Moreton-in-the-Marsh, with special reference to an upper bed wherein the fragments are mostly in a vertical position, some of them having their heavier ends uppermost. He theorizes that the vertical materials were the droppings from melting ice floating down a large river. This river, formed out of one or more of original consequents of the Thames system, existed before the valley of the Warwickshire Avon had been excavated. By one branch, possibly the upper Trent, it drained the Pennine range; by another, possibly the upper Severn, the Welsh hills. Ice formed in the upper waters—in these highlands—enclosing débris, and when a thaw occurred, it floated down to the lower parts of the river. The author notices certain flints obtained from the gravels. Those from the upper bed are quite unabraded; those from the lower bed have their edges worn, and in some cases battered, while sometimes they are peculiarly flaked as if artificially worked. The author surmises that the date of the gravel, if formed by a river-system as supposed, is Pliocene.

3. "On the occurrence of Pebbles of Schorl-rock from the South-West of England in the Drift-deposits of Southern and Eastern England." By A. E. Salter, Esq., B.Sc., F.G.S.

A set of twelve representative specimens, consisting essentially of quartz and tourmaline, have been looked over by Professor Bonney, who informs the author that they consist mainly of felspathic grits, schorl-rock, etc., similar rocks to which occur in the South-West of England. The most westerly point at which the pebbles have been detected is on Great and Little Haldon Hills, 800 feet above Ordnance datum, where they are of larger size, more abundant, and coarser-grained than elsewhere. Thence they are traced to the north and south sides of the Thames Basin, and into East Anglia at Walton-on-the-Naze, Aldeburgh, etc. There is a general decrease in height in the deposits in which the pebbles occur, in passing from west to east, and the pebbles appear to have taken two main courses—one along a peneplain west to east from Dartmoor, the other from south-west to north-east across England. The pebbles are absent from the Weald and from the district around Bagshot, from the Hampshire Basin and its bounding hills (with the exception of the extreme south), and from the highest and presumably oldest gravels north of the Thames.

CORRESPONDENCE.

SUB-OCEANIC PHYSICAL FEATURES.

SIR,—I take up my pen with unusual pleasure on this occasion, as it is for the purpose of welcoming an adherent, and removing misapprehension from the mind of a supposed opponent. I welcome the adherence to my views of so able a physicist as the Rev. Osmond Fisher, and I hope to be able to remove misunderstanding as to my meaning from the mind of Mr. Jukes-Browne.[1]

Let me assure Mr. Fisher that I am well acquainted with the paper by the late Mr. Godwin-Austen, which he quotes at length, and that in the paper on the sub-oceanic physical features off the coast of Western Europe (at present only in manuscript) I commence my statement by calling attention to Mr. Godwin-Austen's remarkable communication to the Geological Society. I wish also to add that, in speaking of the subaerial origin of 'the grand escarpment,' he is correct in inferring that I included 'wave-action' along a coastline, as Professor Spencer has also done in his article in the GEOLOGICAL MAGAZINE, January, 1899, p. 17. There is one point, however, in Mr. Fisher's letter, towards the end, which I would ask him to reconsider. It is quite true that the physical features on opposite sides of the Atlantic, now submerged, do possess a remarkable similarity (though not identity) of form; but I can scarcely suppose him to mean (as his language seems to imply) that it is in consequence of their original union on two sides of a 'rent'; an impossible hypothesis.

I shall now endeavour to reply, as concisely as possible, to the three points which have called forth rather severe criticism on the part of Mr. Jukes-Browne.

(1) As regards the term 'escarpment,' as applied to the descent leading down from the platform to the abyssal regions of the ocean, I quite admit that the term is not strictly geological as usually understood. For, although there may be portions of this long line of slope where the strata may be in such a position, and of such a character, as to constitute a true geological escarpment if under the air, yet we know so little of the rocks otherwise than by inference that we cannot pretend that this is the case. Under the circumstances, therefore, and notwithstanding the support of Professor Spencer for the term 'escarpment,' I am quite willing to recognize the force of Mr. Jukes-Browne's objections, and to drop that term in favour of 'Declivity.' This term, therefore, I intend to use, with the retention of the word 'Grand,' in my paper when published.[2]

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[1] Letters, GEOLOGICAL MAGAZINE, Sept., 1898, p. 429, and Nov., p. 527.

[2] *An abstract of the* paper will be published by the Royal Geographical Society *in March; but the full* paper later on, by the Victoria Institute.

(2) Next, with regard to the formation of the Grand Declivity by subaerial action, I now see where the obscurity of my language led Mr. Jukes-Browne to misunderstand my meaning when he says, "How the existence of river-made valleys can possibly prove the declivity to have been made by subaerial agencies passes my comprehension." But Professor Spencer,[1] as also Mr. Fisher, have recognized that under the term 'subaerial agencies' I included the erosive action of waves and currents along lines of cliff, whether of emerging or subsiding land, just as we see along our own coasts at the present day. In endeavouring to maintain, against some objectors, that these sub-oceanic features were produced under the air rather than under the waters of the ocean, I lost sight, for the moment, of the very obvious fact that rivers and waves were the chief agents in their formation. I hope I have now made my meaning clear; but before leaving this point, I wish to add that, although both during emergence and subsidence the action of the Atlantic waters in cutting back the coast was doubtless in operation, it seems most probable that the greatest amount of work was done during the doubtless prolonged pause which intervened when the change from the one direction of movement into the other was taking place; during this period, also, river-erosion was probably most active.

(3) The last important point on which I shall touch is with reference to the geological age of these sub-oceanic features. I have assumed that it was during the prolonged period extending from the close of the Eocene into the Post-Pliocene. Mr. Jukes-Browne asks, "Is there any reason why the formation of the escarpment and the union of Great Britain with Iceland should not have taken place in the Eocene period?" (Geol. Mag., 1898, p. 430). Doubtless, there was an incipient uprising and shaping of our coasts at this epoch, as indicated by the discordant relations of the Lower Tertiary to the Cretaceous strata. But, while admitting with Mr. Jukes-Browne the probability of an incipient uplift, I strongly hold that it was not till the succeeding Miocene stage that the great elevatory movement of the Atlantic bed determinately set in. The powerful terrestrial movements during this and the succeeding Pliocene age, all over the European area and beyond, accompanied by denudation, need not here be insisted on. But the point which concerns our present inquiry is this: that the courses of the existing British and Continental streams having been mainly determined during these later Tertiary periods, we have a clue to the age of those now under the ocean, as they were once in physical connection with them. The subject is, however, too wide and intricate to be fully dealt with here; and I must hasten on to my last point, namely, the epoch of maximum elevation; and in answer to the second part of Mr. Jukes-Browne's question (quoted above), I reply, that whether or not this connection was established in the Eocene period, it is clear that it was continued (or repeated) in Pleistocene times, inasmuch as

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[1] *Geol. Mag., January*, 1899, p. 17.

the fauna and flora are identical, and both are of Recent age; a physical connection would necessitate an uplift of the ocean bed to a *minimum* extent of 550 fathoms.

As regards the epoch of *maximum* elevation, I have already given my reasons for holding that the extreme cold of the Glacial Epoch was the direct result of land elevation on both sides of the Atlantic (see my paper on "Another Possible Cause of the Glacial Epoch," Trans. Vict. Inst., 1898); under this view, it follows that the intensest cold would probably occur during the epoch of maximum elevation, namely, the early stage of the Glacial Epoch. I need not further dwell on this point, which I have attempted to deal with in the paper referred to.

But this communication has extended far beyond my original intention, and I must bring it to a close. It seems to me that this correspondence has "cleared the air," and that between the views of Professor Spencer, Mr. Jukes-Browne, and myself there is but little difference; or the difference is unimportant.

Edward Hull.

THE HORIZON OF *DINOCYSTIS BARROISI*.[1]

Sir,—Professor G. Dewalque, writing in your February number (n.s., Dec. IV, Vol. VI, p. 94), gently turns the Famennian beds of the Condroz right way up again from the reversed position into which an annoying slip on p. 543 of my paper had thrown them. For this friendly intervention he has my thanks, but with his main thesis I am unable to agree. The question at issue is the horizon of *Dinocystis Barroisi*; to this all the rest is subsidiary. Let us make the question clear by printing the list of the horizons of the Famennian, in descending order, as given in "Légende de la Carte Géologique de Belgique, etc.," 8vo, Bruxelles, 1896.

Devonien supérieur.

Famennien supérieur.

Assise de Comblain-au-Pont [=Etroeungt Limestone].
Assise d'Evieux.
Assise de Monfort.
Assise de Souverain-Pré.

Famennien inférieur.

Assise d'Esneux.
Assise de Mariembourg.
Assise de Senzeilles.

This list does not imply an absolute vertical succession: it appears, for instance, that the Assise d'Evieux, with its rich flora, may be a more littoral facies of the Assise de Monfort, while the Assise d'Esneux may be the arenaceous equivalent of the more shaly beds of Mariembourg.

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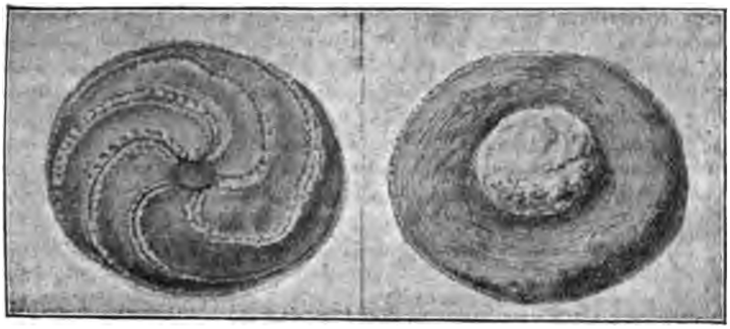
[1] See Geol. Mag., n.s., Dec. IV, Vol. V, pp. 543-8 (December, 1898). Footnote 1 on p. 547 explained the name *Dinocystis* as derived from δεινός, *terrible*. Although this seemed peculiar, it did not occur to me that Dr. Jaekel must have intended to *derive it from* δινεῖν, *to whirl round*, in allusion to the marked curvature of the radial *grooves. Thus regarded*, the name is highly appropriate.

Now my argument was that *Dinocystis Barroisi*, being what was usually called an *Agelacrinus*, was with little doubt the same as the "*Agelacrinus*" which Mourlon cited in 1881 ("Géol. de la Belgique," ii, p. 23) from "Assises de Montfort et d'Evieux"; and therefore that our specimens of *D. Barroisi* also came from these beds, "the uppermost member of the true Upper Devonian." Professor Dewalque states that, "for important reasons," he believes the *Agelacrinus* of Mourlon, 1881, to be the same species as a certain "astérie," to which Mr. Mourlon referred in 1875 as being in "collection Malaise." This "astérie," according to Prof. Dewalque, is a specimen of his *Protaster Decheni*, from the Assise d'Evieux. If these beliefs were justified, it would follow that *Dinocystis Barroisi* was not the same as the *Agelacrinus* of Mourlon, and it would be referred to the same horizon on no better evidence than an inaccurate dealer's label.

Since the validity of Professor Dewalque's criticism entirely depends on "important reasons," we should be warranted in disregarding it until those reasons have been published. But the high authority of my critic, no less than the difficulty of attributing so incomprehensible an error to the learned director of the Service Géologique de Belgique, has led me to investigate the question afresh.

The results more than justify my former inference.



Dinocystis Barroisi: photographic reproduction (reduced to $\frac{8}{9}$) of a pencil-drawing made for Mr. Mourlon in 1881, from the specimen then referred by him to *Agelacrinus*. The position of the anus was not observed by the draughtsman; it may well have been in the rather irregular interradius to the right in the drawing of the actinal surface.

Professor C. Malaise kindly informs me that the above-mentioned "astérie" is still in his collection, that it is a specimen of *Protaster Decheni*, Dewalque, and that the bed at Walcourt from which it came belongs, in his opinion, to the Assise d'Esneux (not the Assise d'Evieux, to which the type-specimen is now referred).

Mr. Mourlon most courteously sends me a drawing, here reproduced, of the specimen mentioned by him as "*Agelacrinus*" in 1881. It is not the "astérie" of Professor Malaise; it is not a *Protaster Decheni*, or any kin thereto; but it is a fine specimen of an Edrioasteroid, as large as, and more perfect than, the British Museum specimen E 7581, with actinal and abactinal surfaces clearly shown; and it belongs incontestably to *Dinocystis Barroisi*. F. A. Bather.

British Museum (Natural History).
February 5, 1899.

OBITUARY.

WILLIAM COLCHESTER, J.P., F.G.S.

Born July 21, 1813. Died November 15, 1898.

Amongst geologists and agriculturists the name of William Colchester will always be associated with the Suffolk Crag and the Cambridge Greensand, and the exploitation of these deposits as sources of artificial manure for the farmers, and which have so largely added to the fertility of the soils, not only at home but in all parts of the civilized world. Coming of a Gloucestershire family, William Colchester was the eldest son of the late Mr. Benjamin Colchester, and spent his early life at Dedham, near Colchester, Essex. Like the late Sir Joseph Prestwich, he was educated at University College, London, and it was originally intended that he should follow the profession of an architect. In early life he travelled much in Italy, studying classic and mediæval architecture. He afterwards visited Russia, chiefly in order to learn the Slavonic language. On his return to England Mr. Colchester became identified with the late Mr. John Chevalier Cobbold, formerly M.P. for Ipswich, in connection with the importation of timber. In course of time Mr. Colchester associated himself with the ports of Ipswich and London in the carrying trade, and became a large shipowner. This led to the development of an extensive ship- and barge-building industry at the Cliff, Ipswich, which he carried on in conjunction with his other business for many years.

Some idea of the extent of this shipping business may be gathered from the fact that the fleet of vessels belonging to the firm at that time numbered more than thirty; whilst the fleet of shrimpers built and equipped by him fifty years ago which sail from Harwich are still known as 'Colchester's Fleet.' They were originally used for dredging up *septaria* from the London Clay off the port of Harwich.

The concretions known as 'septaria' form the raw material from which Roman or Portland cement was manufactured, an industry extensively carried on by Mr. Colchester fifty years ago. These dredging operations were also of great importance in deepening the channel at the mouth of the River Orwell, which, owing to the set of the tides, was liable to be obstructed by the formation of a bar across its estuary.

In 1843, after an excursion in the Crag district in the neighbourhood around Ipswich in company with his friends Colchester and

Prestwich, the Rev. Professor Henslow called the attention of the Geological Society of London to the great beds of shingle at Felixstowe, where the pebbles contained so large a proportion of phosphate of lime that he was "convinced they must all be considered as of *coprolitic origin*," and amongst which he found the fossil tympanic bones of several kinds of whales. The practical mind of William Colchester soon enabled him to turn this to account, and, after consultation with Mr., now Sir, John Lawes, a company was formed known as Lawes's Chemical Manure Company, of which Mr. Colchester was Chairman for many years.

The first area worked by this Company for obtaining the raw material for the production of artificial phosphates for agricultural purposes was in the Suffolk Crag, and extended from Felixstowe through Melton, Bawdsey, Orford Castle, to Sutton Haugh.

It was fortunate that Mr. Colchester was a geologist in addition to being a keen man of business, otherwise the wholesale destruction of the Suffolk Crag over this large area, in the search for artificial manure, would have resulted in an irreparable loss to geological science; but during the whole period the diggings were being carried on, the workmen were encouraged to collect and preserve the more interesting specimens of teeth and bones of mammalia and fishes, which form no inconsiderable part of the Crag nodules, and of which the museums of Ipswich and York, the British Museum, and many others contain abundant examples. The Crag deposits of Suffolk and Norfolk yield numerous remains of Pliocene Vertebrata mingled with derivative fossils from earlier Miocene and Eocene strata.

Since the opening of the phosphate diggings, large collections have been made by the late Mr. Edward Charlesworth, F.G.S., Messrs. Jas. Baker and W. Whincopp, of Woodbridge, Sir Joseph Prestwich, the Rev. F. Canham, and others. Mr. Colchester's own collection was lately given to the Ipswich Museum, where Mr. Canham's collection (purchased for the town by the late Sir Richard Wallace) is also preserved. The other collections are now mostly acquired by the British Museum, and, through the liberality of Mr. William Reed, F.G S., for the York Museum.

Large works were erected at Ipswich for the crushing and grinding to fine powder of the raw coprolite, and it was no uncommon thing in those days for frequent special trains to be running laden with thousands of tons of the newly discovered mineral. In the experience of the late manager, we are told that sometimes as many as fourteen vessels, steamers, etc., have been waiting their turn to load at Mr. Colchester's works, in the Cliff Bight, Ipswich.

Mr. Colchester also acquired large chemical works at Rainham, and at his death was still a proprietor of land around that place. He was also the originator of the "Manganese Bronze Company," and was the inventor and manufacturer of steam-ship propellers for the motive-power of our great ocean-going liners.

After the cessation of the Suffolk Crag Coprolite Works Mr. Colchester became interested in the Cambridge Greensand Coprolite Diggings, and joined Mr. T. T. Ball in the Burwell Works. Some twelve years ago he restored the old mansion of Burwell Hall, and rebuilt it much on the lines of Springfield House, Ipswich, his then residence, and thereafter he made his home at Burwell.

He was elected a Fellow of the Geological Society of London in 1857 (but did not communicate any papers to the Society); he was also elected a Member of the Geological Club in December, 1882.

Mr. Colchester married in 1840 Miss Kate Bright, a daughter of the well-known Maldon family of that name, and in 1890 celebrated his golden wedding, with all his numerous family around him. The surviving four sons and four daughters were present at his funeral with several of his grandchildren.

During Mr. Colchester's long life of 85 years he retained his mental and bodily activity almost to the last, and whilst carrying on an enormous amount of business engagements he found time to form numerous pleasant and lifelong friendships with eminent geologists, and to attend the meetings of the Societies in London and those of the British Association for many years.

PROF. H. A. NICHOLSON, M.D., D.Sc., F.R.S., F.L.S., F.G.S.

Born September 11, 1844. Died January 19, 1899.

(WITH A PORTRAIT, PLATE IV.)[1]

Henry Alleyne Nicholson was born at Penrith; his father, Dr. John Nicholson, was a well-known Oriental scholar, and his grandfather was President of Codrington College, Barbados. He received his early education under Francis Newman and at Appleby Grammar School, and then went to the University of Göttingen, where he worked under Professor Keferstein, the distinguished zoologist. From 1862 to 1867 he studied medicine at the University of Edinburgh, and graduated in this latter year as Bachelor of Medicine and Master of Surgery, taking first-class honours in all subjects, and obtaining the University Gold Medal for his graduation thesis, "On the Geology of Cumberland and Westmoreland"; this was subsequently published, with a dedication to his friend and teacher, Professor Harkness, of Queen's College, Cork, in whose company in the field Nicholson worked out the geology of the districts in question. In addition to the more strictly medical studies of the University he worked earnestly at the Natural Sciences under the teaching of Goodsir, Allman, and Balfour, and graduated as Bachelor of Science in 1866, receiving the Baxter Scholarship in the Natural Sciences, and in the following year he took the degree of Doctor of Science. In 1869 he proceeded to the degree of Doctor of Medicine, and was awarded at the same time the Ettles Medical Scholarship of the University, as the most distinguished student of his year in medicine.

The first position occupied by Professor Nicholson after the conclusion of his brilliant student career was that of Lecturer on

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[1] For permission to reproduce this excellent portrait of our lost friend we are indebted to the editors of "Alma Mater," and to its publishers, Messrs. W. & W. *Lindsay, Aberdeen.*—Edit. Geol. Mag.

Yours very sincerely
H. Alleyne Nicholson

THE LATE PROFESSOR H. A. NICHOLSON, M.A., M.D., F.R.S.,
University of Aberdeen.

Natural History in the Extramural School of Medicine at Edinburgh, and for a short time also he practised medicine. In 1871 he was appointed to the chair of Natural History in the University of Toronto, which he held for three years. During this period he carried out successfully, not only his professorial duties, but also, at the request of the Provincial Government of Ontario, an investigation into the Fauna dredged up from Lake Ontario, and an examination of the fossils of the Silurian and Devonian rocks of the province, of which he made an extensive collection. They were described and figured in two lengthy Reports, which were published by the Government of Ontario. Professor Nicholson was also entrusted by Dr. Newberry, the State Geologist of Ohio, with the description of the Fossil Corals and Polyzoa of that State, and his Report on them, accompanied by five quarto plates of figures, drawn by Nicholson's own hand, appeared in the second volume of the "Palæontology of Ohio."

During his residence in Toronto, also, his "Manual of Palæontology" was first published, and the first part of the Monograph of the British Graptolites was issued in the same year (1872).

It will be readily understood that to a man like Professor Nicholson, with superabundant energy for original scientific work, the somewhat isolated position of Toronto would be less favourable for his special pursuit than a centre of learning within the British Isles, and it is not therefore surprising that he should have availed himself of an opportunity of returning homewards, which occurred in 1874, when he was appointed Professor of Comparative Anatomy and Zoology in the Royal College of Science, Dublin; but before he reached that city he was offered the more acceptable position of Professor of Biology in the Durham College of Physical Science and Medicine. For two sessions he lectured at Newcastle-on-Tyne, and then he accepted the offer, unsolicited on his part, of the Chair of Natural History in the University of St. Andrew's.

At St. Andrew's, where Professor Nicholson remained seven years (1875–1882), he may be said to have created the study of Natural History, and he likewise took a very active part in the extension of University teaching to Dundee, and for several years delivered systematic courses of lectures to the Ladies' Educational Association of St. Andrew's, Dundee, and Cupar. At the same time he found opportunity to carry out an immense amount of original work, more particularly in the investigation of Fossil Corals, on which subject, in addition to numerous minor papers, he published two elaborate monographs—one "On the Structure and Affinities of the 'Tabulate Corals' of the Palæozoic Period," in 1879; the other "On the Structure and Affinities of the Genus *Monticulipora* and its Sub-genera," in 1881. Another important monograph of this period, produced in collaboration with Mr. R. Etheridge, jun., is that on the Silurian Fossils of the Girvan District in Ayrshire. To this original work may be added a popular volume on "The Ancient Life-History of the Earth," fresh editions of the Manual and Text-Books of Zoology, and, in 1879, a second edition of the Manual of

Palæontology, largely rewritten and so increased by the addition of new matter as practically to be considered a new book.

In the Summer session of 1878–9, Professor Nicholson delivered, at the request of the Senate of the University of Edinburgh, the course of Natural History lectures, in the stead of Professor Sir Wyville Thomson, incapacitated by illness, and he also conducted the course during the two following sessions. On the resignation of Sir W. Thomson, Nicholson became a candidate for the Chair, but Professor Ray Lankester, now the Director of the British Museum of Natural History, Cromwell Road, received the appointment, which he shortly after renounced, and the position was then given to Dr. Cossar Ewart. By many of the friends of Professor Nicholson, the slight shown to him by his own University in thus passing over his undoubted superior claims as a teacher, was attributed to the influence of a small faction, whose opposition was stirred up by the independence of Nicholson's views as to the all-sufficiency of the Darwinian theory of Evolution.

In 1882 Professor Nicholson accepted the appointment of Regius Professor of Natural History in the University of Aberdeen, which he held for the remainder of his life. In addition to his official work, he still continued his researches on fossil Corals and Monticuliporoids, and contributed several papers on these organisms to the Annals and Magazine of Natural History and to the GEOLOGICAL MAGAZINE. Some of these papers were written in conjunction with Dr. A. H. Foord and Mr. R. Etheridge, jun. But the most important original work produced at this time was the monograph of the British Stromatoporoids published by the Palæontographical Society (1886–1892). The seventh edition of the Manual of Zoology, which had been wholly recast and almost entirely rewritten, appeared in 1887, and two years later a third edition of the Manual of Palæontology, in which the additions were on a still more extended scale, was published. In this edition the first volume, containing the "General Introduction" and the "Palæontology of Invertebrates," was the work of Professor Nicholson, whilst the second was written by Mr. R. Lydekker.

Coming to a more recent period, the passing into law of the new University Ordinances in Scotland involved a large amount of extra work in connection with the reorganization of the University classes, and to this object Nicholson devoted all his available energy, to the entire exclusion of original research, which he looked forward to resuming at a future opportunity. As part of the revised system, he introduced courses of lectures on Systematic and Practical Geology and advanced laboratory work in the same science, and he voluntarily undertook this geological teaching without extra remuneration. Such practical zeal on behalf of his favourite science was not lost on his students, for the numbers attending the geological course increased from twenty when first started to eighty at the end of three or four years.

Professor Nicholson's ability as a teacher and lecturer was pre-eminent. It has been said of him by an old friend that he was a 'heaven-born' teacher; however this may be, the writer can testify that his lectures, in the early days of his professorial career, were characterized by the same fluent delivery, without a shadow of hesitation, by the same clearness of exposition, making a complex subject appear simple to the understanding, and by the same fulness of illustration, which distinguished them throughout the succeeding years. It is not surprising that these lectures secured the attention of full classes of University students, so that discipline was never called for, and they proved equally as attractive and fascinating to the mixed general audience who heard the courses of Swiney lectures on geological subjects, which, on the appointment of the Trustees of the British Museum, were given by Professor Nicholson for several successive years (1878–82, 1890–94) at South Kensington. Although the delivery of the lectures appeared to be without effort, and as it were natural on the part of the lecturer, they involved no small expenditure of mental energy, and their success was due largely to the careful preparation bestowed on them beforehand. The various subjects were illustrated by numerous well-executed diagrams, all the work of Nicholson's own hand, and these were supplemented by chalk sketches on the blackboard drawn with ready aptitude as occasion required, and, when possible, by demonstration of actual specimens. Nothing was omitted which would be of service in elucidating the subject of a lecture, and the time allotted for it passed all too quickly, at all events on the part of those who listened.

The departments of Science for which Professor Nicholson felt the strongest predilection were Field Geology and Invertebrate Palæontology. For the study of the former, no scenes more favourable could have been chosen than those surrounding his birthplace and the home of his boyhood in the Lake District; here most of his holidays were spent, and rest and renewed vigour obtained in working out in detail the complicated geological structure and collecting the fossils from the rocks for subsequent study. As already mentioned, his graduation thesis consisted of an essay on the Geology of Cumberland and Westmoreland; but previous to this, he had already published, in conjunction with Professor Harkness, a paper of "Additional Observations on the Geology of the Lake Country," and also "On the Coniston Group," announcing the discovery of a rich Graptolite fauna in the Coniston Flags of Sedgwick. Other papers on the Green Slates and Porphyries between Ulleswater and Keswick and on the Borrowdale Series and Coniston Flags appeared in 1871 and 1877. A still more important memoir on the Stockdale Shales, in which the work and the honour were shared equally with his friend Professor J. E. Marr, was brought out in 1888. In this paper the Stockdale Shales were shown to be capable of division into a series of zones based on lithological characters and their contained fossils, mainly graptolites, and additional evidence was thus furnished of the value of these organisms as a means of comparison of Lower Palæozoic rocks of distant areas. A shorter paper by the same authors, which appeared subsequently, dealt with the age and the fossils in the various formations in the Cross Fell Inlier.

Professor Nicholson's researches in Invertebrate Palæontology were concerned mainly with Graptolites, Corals, Monticuliporoids, and Stromatoporoids. He first devoted his energies to the Graptolites, with which some of the beds in the Lake District are crowded, and described those in the Skiddaw Slates, pointing out their close resemblance to the forms in the Quebec Group of Canada. Then followed papers on *Ptilograptus*; *Helicograptus*, a new genus; the Distribution in time of the British species and genera of Graptolites; the Graptolites of the Coniston Flags; British species of *Didymograptus*; and on the genus *Climacograptus*, with notes on the British species of the genus. These detached papers were succeeded by the first part of a detailed monograph on the Graptolites of Britain, in which the history, morphology, the nature and functions of the base, mode of existence, geological distribution, and definition of the various genera of the group were ably treated. Further work was interrupted by Nicholson's residence in Canada, and not again resumed (save in a brief but important paper jointly with Professor Marr, dealing with the phylogeny of the group, which appeared in the GEOL. MAG., Dec. IV, Vol. II, 1895); the task thus relinquished passing thenceforward into the hands of his friend Professor Chas. Lapworth. It is well known that the study of the Graptolites in the rocks of this country is very difficult on account of their compressed condition of preservation, and it required much critical acumen on Nicholson's part to decipher their characters so correctly as he has done.

The marvellous abundance and variety of forms of Corals and Monticuliporoids in the Palæozoic rocks of North America induced Nicholson to make large collections of them during his stay on that side of the Atlantic, and they furnished the materials for many years' study after his return. At the time when he began his work on these organisms, the practice of making thin sections to show their interior structure had not come into vogue; Nicholson was one of the first to appreciate the advantages of this method of investigation, so he procured a lapidary's wheel, and with unwearied diligence set himself to make thin slices, in various directions, of all the forms he studied, and then mount them for the microscope. By this means he was enabled to ascertain the real structure of the fossils, and to define their characters with a precision not previously attainable. The fresh knowledge thus obtained of the actual anatomy and systematic relations of the Palæozoic Corals and Monticuliporoids, formed the basis of the two elaborate monographs on these groups, and gave to them a special value and interest. Nicholson's determinations of the systematic affinities of some of these forms were, as he himself acknowledged, of a tentative character, and the tendency of recent opinion with respect to the Monticuliporoid group is to associate it with the Polyzoa rather than with the Corals, where it had been placed by Nicholson, but this in no wise affects the accuracy of his descriptions and figures of the various forms of the group given in these monographs.

The Monograph of the British Stromatoporoids will probably be regarded as Nicholson's most important contribution to Palæontology. The dubious character of these fossils is plainly indicated by the various conflicting opinions held about them by many leading palæontologists, and even our author found it needful to abandon his own earlier views of their nature. Nothing daunted, however, he continued his researches, and gathering his materials from the Silurian and Devonian rocks of Britain and North America, also from the Silurian of Esthonia and the Devonian deposits of Germany, he made personally more than a thousand microscopic slides from the specimens. The wonderful variety and beauty of the minute structures shown in these slides were represented in perfect detail in the drawings, made by Nicholson himself, which occupied the twenty-nine quarto plates and the woodcuts in the text of this monograph. As the result of these extended investigations, Nicholson was enabled to show conclusively that the Stromatoporoids belonged to a special division of the Hydrozoa, a relationship which had been already suspected by Lindström and Carter. It is satisfactory to know that the grand series of specimens and the microscopic sections made from them, which formed the basis of this model monograph on the Stromatoporoids, have passed into the possession of the British Museum (Natural History), Cromwell Road, and we believe that the typical specimens of Nicholson's collection of Graptolites are also in the same institution.

Professor Nicholson further took great interest in the nature of certain anomalous organisms which are concerned in the formation of some of the Palæozoic Limestones, such as *Solenopora*, Dyb., *Mitcheldeania*, Weth., and *Girvanella*, Nich. & Eth., and described and figured them very fully, and he also very satisfactorily cleared up the doubtful points relating to the structure of the genus *Parkeria*, Carp.

But Nicholson's services to his favourite sciences were not confined to original researches, for his Manuals and Text-books of Zoology and Palæontology may deservedly be considered as important adjuncts to their advancement. They are characterized by clearness and perspicuity of style, and by the number and excellence of the figures and diagrams with which they are illustrated. That they are widely used is shown by the number of editions which have been called for, and in each successive edition there is such a large amount of additional matter as to entitle the book to be regarded as new. This is well exemplified in the "Manual of Palæontology," the first edition of which was a single volume of 601 pages and 401 figures, whilst the third edition comprises two volumes, with 1,624 pages of letterpress and 1,419 figures. Only the first of these volumes, which deals with Invertebrate Fossils, is by Nicholson's own hand; it is rendered especially valuable to the practical student by the careful descriptions and figures of the microscopic structures of the different kinds of organisms occurring in the rocks, so that they can be recognized in thin sections. This volume is the most complete general work on Invertebrate Palæontology which has appeared in the English language.

Only some of the principal works of Professor Nicholson have been mentioned above; besides these, a large number of separate papers on geological and palæontological subjects were contributed by him to the journals of scientific societies and to scientific periodicals. So far as can be ascertained, there are of these 138 entirely written by Nicholson, and 27 joint papers, his co-workers in the latter having been Mr. R. Etheridge, jun., Dr. A. H. Foord, Professors Harkness, Lapworth, and Marr, and Dr. Murie.

Professor Nicholson was elected a Fellow of the Geological Society in 1867, of the Linnæan Society in 1876, and of the Royal Society in 1897. In 1879 the Council of the Geological Society awarded to him the Lyell Fund and in 1888 the Lyell Medal, "in appreciation of his valuable researches among the older Palæozoic rocks, both in the Old and New World, and of his continued and patient investigations into the organization of some of the obscurer forms of life which abounded at the period of the deposition of these rocks."

Even beyond the intellectual ability and high qualifications which characterized Professor Nicholson as a teacher, his geniality and sympathetic disposition won for him the hearty respect and admiration of his students and friends. All those who were brought in contact with him were charmed and attracted by the genuine cordiality and frankness which speedily removed the feeling of restraint and enlisted one's full confidence in him. To fellow-workers in his favourite branches of science he always extended the true spirit of comrade- [redacted]

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. VI.

No. IV.—APRIL, 1899.

ORIGINAL ARTICLES.

I.—On the Eastern Margin of the North Atlantic Basin.

By Wilfrid H. Hudleston, M.A., F.R.S., F.L.S., F.G.S., etc.

(Concluded from the March Number, p. 105.)

Part II. — The Icelandic Shallows.[1]

(PLATES V, VI, and VII.)

QUITTING the more northern parts of the great Atlantic depression, we have next to consider an extensive water-space of a much shallower character. Here the volcanic masses of Iceland and the Færoes with their submarine attachments have produced a marked effect on the depths of the ocean. The Norwegian Atlantic connects with the main Atlantic by three straits, whose central channels present the following depths at their shallowest:—

The Færoe-Shetland Channel	319 fathoms.
The Færoe-Iceland Platform	277 ,,
The Denmark Straits	319 ,,

The Færoe-Shetland Channel, sometimes known as the Lightning Channel, is one of great interest to us. It runs up from the axis of the Norwegian Atlantic in depths of about 600 fathoms, when it suddenly abuts on the Wyville Thomson ridge, which is a kind of submerged causeway running from the Shetland bank to the Færoe bank. The extreme depth, in the centre, to which this ridge is now submerged, may be taken at 319 fathoms, or 1,914 feet. To make things perfectly safe, we should require an elevation of this part of the sea bed to the extent of 2,000 feet in order to walk over to Iceland without wetting our shoes, and an equal amount of elevation in the Denmark Straits would enable us to extend our journey to Greenland. But it must not be supposed that an elevation of 2,000 feet would do more than produce a very narrow neck of land; and even an elevation of 3,000 feet, if Mohn's chart is to be relied on,[2] would still confine us to the use of the narrow Wyville Thomson isthmus. It should be noted that the Lightning Channel runs up in almost direct continuation of the axial depths of the

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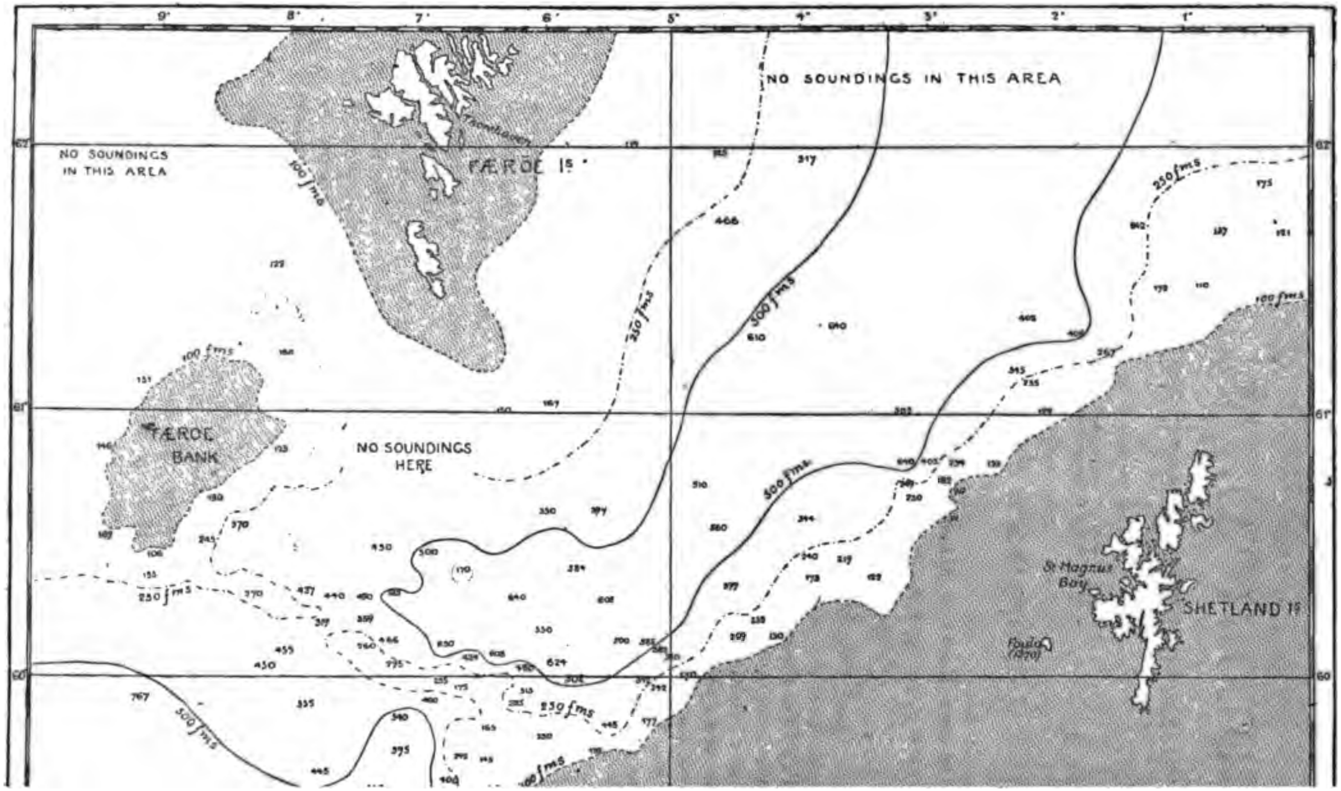
[1] Figures 2, 3, and 4 (forming Plates V, VI, and VII), being reductions of portions of the Admiralty charts, are specially intended to illustrate Parts II and III.

[2] According to Bartholomew's map illustrating Nansen's paper in the Geographical Journal, the Lightning Channel is bridged by *two* submerged necks of land.


9°
8°
7°
6°
5°
4°
3°
2°
1°
62°
61°
60°
NO SOUNDINGS IN THIS AREA
NO SOUNDINGS IN THIS AREA
FÆROE IS
100 fms
250 fms
500 fms
FÆROE BANK
NO SOUNDINGS HERE
St Magnus Bay
SHETLAND IS
Foula (1370)

Norwegian Atlantic, to meet on the other side of the ridge the great embayment of the British Atlantic, which lies betwixt Ireland and the Rockall platform.

Throughout this part of the ocean the suboceanic continental slope is not always to be made out with certainty. It is very perceptible off Romsdal in Norway, but less distinct between that coast and Shetland, off the mouth of the North Sea. Here the contours are more gradual even than off the mouth of the Barents Sea. Nevertheless, it is within this marginal slope that all the terrigenous deposits lie, whilst outside, i.e. to the westward beyond the centre of the Lightning Channel, all the known land, and presumably most of the submerged land, is of igneous origin.[1] According to my view, the continuation of the suboceanic continental slope is to be found along the south-east side of the Lightning Channel, which is tolerably steep in places. Thus, about 55 miles W.N.W. of St. Magnus Bay, in the mainland of Shetland, the edge of the Continental platform lies in about 90 fathoms of water; from this edge the submarine slope descends to 640 fathoms in the space of 15 miles, showing an inclination of 1 in 24, or 2½°. This is the steepest declivity I can find in connection with the Lightning Channel.

South of the Wyville Thomson ridge the suboceanic continental slope may be traced in the Vidal bank, which runs parallel with the Hebrides; here the contours are rather wide apart and the inclination is gradual. The Vidal bank forms the eastern margin of that great embayment of the Atlantic which runs up between Scotland and Rockall. The Rockall bank is evidently of igneous and not of terrigenous origin, and may be classed among the group of oceanic islands; it is probably in alignment with the Færoe bank, 280 miles towards the north-west, though never actually connected with it. The rock itself is only 70 feet above the surface of the water, and consists of an acid igneous product, named by Professor Judd 'rockallite,' but most of the specimens dredged from the bank are said to be of basaltic character. (Trans. Roy. Irish Acad., xxxi, 1897, p. 39.)[2]

Following the submerged continental slope in continuation of the Vidal bank, a considerable change is noted off the coast of Connaught, where the contours close in rapidly, and a deep embayment of the Atlantic approaches within 80 miles of Broadhaven. South of this embayment there is a large submerged platform, at a lower level for the most part than the usual continental shelf. This has a very irregular surface, with depths ranging from 130 to 240 fathoms, and it has its termination seawards in the direction of the Porcupine bank. This irregular platform causes a westward bulge of the Continental submergence, which here presents an edge which is also very irregular and unequal in its depths. In places the suboceanic slope is pretty steep, especially where it faces the north. Thus we find a drop from 135 to 1,350 fathoms in a distance of 23 miles, giving an inclination of 1 in 17, or 3½°. I cannot find anything steeper than this in connection with the Porcupine bank, although it has been stated that the slopes are precipitous.

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[1] Dr Thoroddsen ("Exploration in Iceland") speaks of fragments of a tableland, originally connected, forming a 3,000 feet thick layer of breccia, which covered the whole inner surface of Iceland, and which has been for the most part removed by erosion; the strata underlying the breccia is everywhere Tertiary basalt. Unfortunately, the author does not say of what the breccia consists. (Geographical Journal, November, 1898, p. 497.)

Postscript.—In a letter dated Copenhagen, December 12, 1898, Dr. Thoroddsen states that he refers to the ancient volcanic palagonite breccia with smaller and larger fragments of basalt, dolerite, etc. It is obvious, therefore, that, so far as we know, all the materials which go to form this large island are of igneous origin, not excepting the Tertiary leaf-beds, which appear to owe their mechanical sediments exclusively to this source.

[2] For a notice of Rockall, see infra, p. 163.

Before going south of the Porcupine bank, it may be convenient to consider for a moment the possible geological history of the Atlantic shallows, as we may term that part of the ocean which lies betwixt the British Isles and the south-east coast of Greenland. That some sort of a bridge across the Atlantic may have existed during portions of Tertiary time in these quarters seems not an incredible supposition. Both botanists and zoologists require it. We have already seen that an elevation of 2,000 feet would suffice to effect a land communication between the British Isles and East Greenland at the present day. In a volcanic region like this we may readily concede such a communication by means of sporadic islands, involving local uplifts to the amount of 2,000 or even 3,000 feet, without postulating such a general uplift as would make, for instance, the coastline of the North of Scotland coincide with the 500-fathom line. No doubt such a state of things is regarded as probable by eminent British geologists, who differ chiefly as to the period when this occurred. It is impossible on the present occasion to do more than allude to such views, and I am by no means prepared to deny that something of the kind may have taken place in Middle Tertiary time, though I fail to perceive the absolute necessity for it. With respect to the general effect of the partial bridging of the Atlantic upon the theory of the permanence of ocean basins, bearing in mind the volcanic nature of the region in question, we may regard the Atlantic shallows as an oscillating area which lies athwart the general trend of the great meridional depression. Under certain circumstances this oscillating area may break the continuity of the great Atlantic depression, and even bridge it for a time.

It would be interesting at this stage of the inquiry to ascertain how far the views of Professor Spencer, as stated in a recent communication to the GEOLOGICAL MAGAZINE, are really applicable to this side of the Atlantic; and whether a study of the Admiralty charts affords any confirmation of his statements or his theories. It is not necessary to refer to the other side of the Atlantic beyond remarking that Professor Spencer, having long studied the region of the Caribbean Sea — perhaps the most unstable on the surface of the earth — appears to have conceived exaggerated notions as to '*epeirogenic*' uplifts on both sides of the Atlantic. An elevation

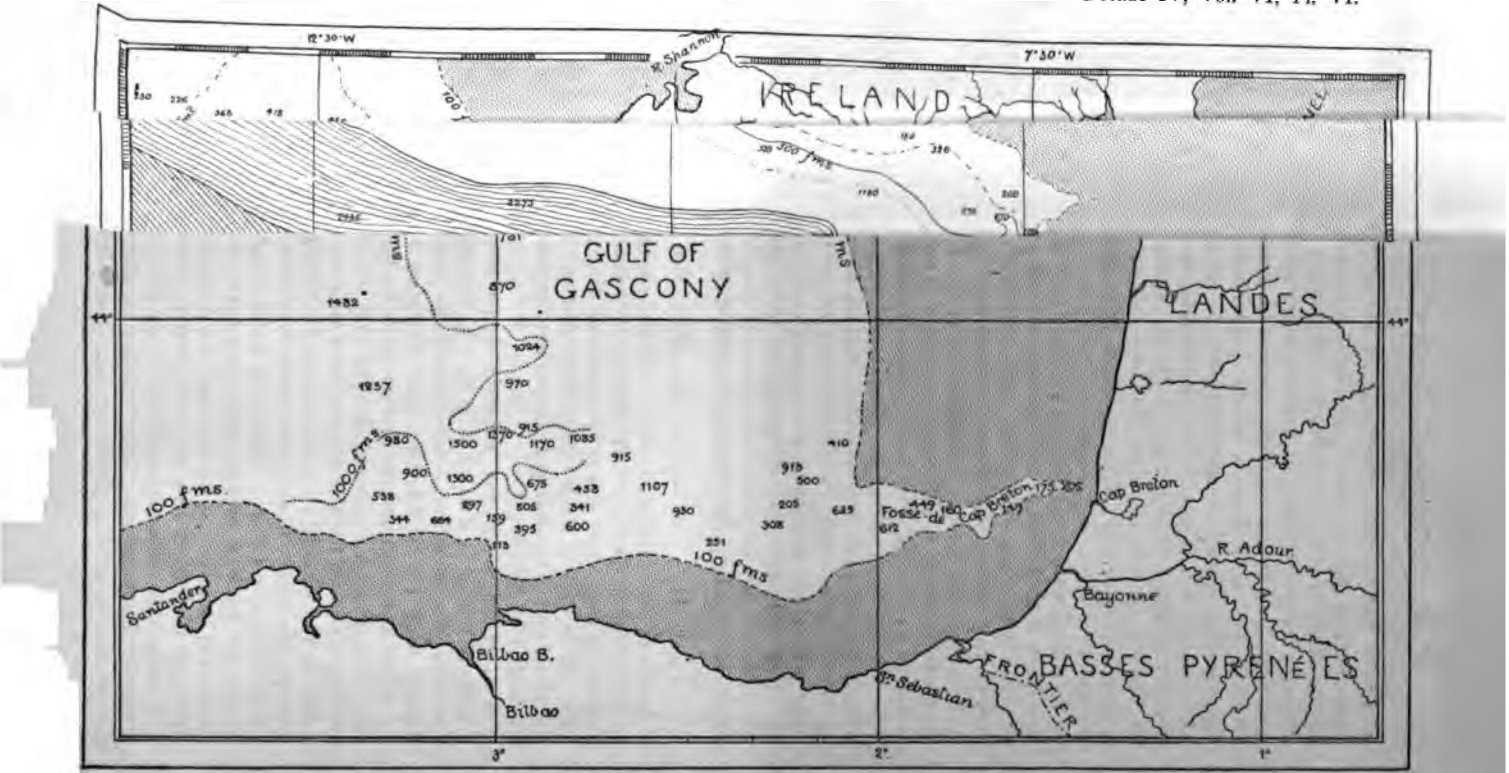

FIG. 4.—The Gulf of Gascony, with the Fosse de Cap Breton.

Reduced from No. 1,104 Admiralty Chart. The water-space within the 100-fathom line is stippled.

English Channel respectively. Immediately south of this occurs the great plunge into the depths of the Bay of Biscay. The soundings along the face of the suboceanic slope hereabouts are very irregular and puzzling; so much so that it is not easy to deduce any mean angle of inclination. This irregularity in the soundings seems more or less to prevail until the 2,000-fathom contour is reached, beyond which the ocean floor becomes much flatter, the depths ranging from 2,200 fathoms to 2,768 fathoms in the centre of the Bay. At La Chapelle bank, which is about 125 miles W.S.W. of Ushant, there is a fall from the 100-fathom contour to 1,900 fathoms in about 20 miles. This is rather steeper than 1 in 10, or about 6°. No rock is marked in these soundings, but deposits of a varying character.

Following the course of the suboceanic slope for about 100 miles south-east of La Chapelle bank, there is a third remarkable deflection of the contours, similar to those indicated off the Little Sole bank and La Chapelle bank. To judge from the soundings there are some curious features here. The distance between the 100-fathom line and the 2,000-fathom line is only 23 miles, giving a mean slope of about 1 in 11 or nearly 5°. But there are greater irregularities than these. For at one spot 600 fathoms is marked just outside the 100-fathom line; whilst in another, further out to sea, a distance of about seven miles, separate soundings of 880 fathoms and 2,100 fathoms respectively, thus giving a slope of 1 in 5 or 11°. In this latter case the irregularity is not connected with the edge of the 100-fathom platform, but may be said to belong to abyssal depths.

Further towards the south-east, off the town of La Rochelle, the following conditions obtain. The continental platform, down to the 100-fathom line, is about 130 miles wide, but the terminal edge is pretty sharp, since we obtain a depth of 2,000 fathoms in the next 22 miles. This gives about the same angle of inclination for the suboceanic continental slope as at La Chapelle, and may perhaps be taken as representing the steeper averages on the French side of the Bay of Biscay, viz. 6° or thereabouts.

The head of the Gulf of Gascony presents some remarkable features which have long attracted attention, though their full import is by no means certain. Here the coasts of France and Spain almost form a right angle to each other, whilst the direction of the suboceanic slope, flanking the Bay of Biscay, is shifted from south-east to nearly due west. The contours at the head of the Bay are somewhat confusing, and this is made worse by a number of incomplete soundings. The respective peculiarities of the French and Spanish territories are to a certain extent prolonged under water, so that the low-lying coasts of the Gironde and the Landes are fully 100 miles distant from the 1,000-fathom contour, whilst the more mountainous Spanish coast near Bilbao is less than 20 miles from it. Almost exactly in the angle, at the very head of the Gulf of Gascony, the 100-fathom platform, here about 30 miles in width, is pierced by *the Fosse de* Cap Breton, which has already a depth of 205 fathoms close to the coast, and which may be traced for 30 miles out to sea until it attains a depth of over 600 fathoms.

This curious place has generally been regarded as the submerged channel of the predecessor of the river Adour, which now enters the sea a few miles to the southwards. To this point I will draw attention presently. Meanwhile there are a few hydrographical details in connection with this submerged channel which might be mentioned. Like so many sunken channels and fjords, not excepting the so-called Channel of Norway, it is very deep at the head, deeper in fact than in any other portion of the first 15 miles. There are also indications of a lateral channel (a short cirque having a depth of 336 fathoms). The mouth is about 10 miles across, and has a maximum depth of 530 fathoms below the submerged continental shelf. This gives a slope from the edge of the shelf to the centre of the channel of 1 in 8, or 7°.

Thirty-five miles to the westward another channel is marked on the chart, in presumed continuation of this one; it is situated about 30 miles to the north of the town of Bilbao. In this channel depths ranging from 1,000 to 1,500 fathoms occur, apparently sunk in a submerged platform, which itself has an extremely irregular surface. A map of the soundings at this place is given by Professor Milne, who quotes it as a locality notorious for cable fracture.[1] He states that the fractures usually happen in the month of March, when sometimes portions of the cable, four or five miles in length, are buried. The fractures are attributed to the action of a submarine current, caused by the piling up of surface water, cutting the prolongation of a river bed with steep walls; these walls when undercut are believed to fall in such masses as to bury the cable. No rock is marked in these soundings, which yield clay, stiff clay, mud, and sand. In this locality the 100-fathom line lies 12 miles off the coast; and from this edge to the 1,500-fathom sounding in the supposed channel is a distance of 11 miles. This gives a mean slope of 1 in 7, or 8°, but pitches much steeper than this in all probability occur. There are several indications that this depth of 1,500 fathoms represents a hole rather than a channel, for the next sounding seawards shows only 1,250 fathoms.

Certain bathymetrical features in connection with the Bay of Biscay may be mentioned here. The deepest sounding shown on the chart (No. 1,104), viz. 2.788 fathoms, is about 100 miles north-west of the supposed channel or cañon of Bilbao. From this depth the floor of the bay, according to the soundings, rises very slightly towards the ocean. If this floor was uplifted equally to the extent of 2,700 fathoms, or 16,200 feet, there would remain a depression of limited extent, 88 fathoms deep, about 100 miles N.N.W. of Santander; all the rest of the floor of the bay would be dry land. Generally speaking, deep water follows pretty closely on the Cantabrian chain. In the vicinity of Cape Ortegal, where the coast of Spain begins to trend south-west, before assuming a southerly direction off Cape Finisterre, there are cases where the suboceanic continental slope is very steep. I will give two instances. (1) Off Rivadeo the 100-fathom platform is of unusual width for this coast—nearly 30 miles, in fact; from the edge of this platform a depth of 1,130 fathoms is obtained in the next 5 miles, giving an incline of 1 in 4, or about 13°. It is probable that this is a hole, and there are indications of still steeper gradients in the vicinity, since at some little distance outside the edge of the shelf a small bank is marked with only 63 fathoms of water, within 3½ miles of the depth in question; this shows a gradient of nearly 1 in 2, or 25°. (2) Exactly off Cape Ortegal itself the 100-fathom platform has a width of 15 miles; from the edge of this platform a depth of 2,515 fathoms is obtained in the next 13 miles. This gives a gradient of 1 in 5, or 11°, for the suboceanic continental slope off Cape Ortegal. In this case, if we reckon the total distance from the coastline rather than from the edge of the continental shelf, we obtain a fall of 2,515 fathoms in 28 miles, showing a gradient of 1 in 10, or rather less than 6°.

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[1] Geographical Journal, September, 1897, p. 273.

It is now time for me to glance briefly at some of the geological inferences which have been drawn from the bathymetrical conditions made known in connection with the Bay of Biscay and its surroundings. It will be hardly necessary to say that Professor Spencer sees cañons, cirques, and escarpments in all these things; whilst in Professor Hull the American epeirogenists have found an able ally on this side of the Atlantic, as shown in his recent "Investigations regarding the Submerged Terraces and River Valleys bordering the British Isles."[1] Professor Hull wields his pencil so skilfully under the guidance of the scientific imagination that we cannot fail to be interested in his charts and diagrams, even if we do not in all cases agree with his interpretations.

So long as Professor Hull confines himself to tracing the old river-courses cut in the continental shelf he is pretty safe.[2] This latter represents an old area of emergence of considerable antiquity, and although the edge of the platform is not always in exactly 100 fathoms, yet it is so nearly on that level for great distances as to give an idea of uniformity. It is obvious that the angle, or 'edge,' formed by the submerged platform with the suboceanic continental slope is a feature of considerable importance, and any marked indentations of this edge are worthy of careful notice. The two indentations of the 100-fathom platform in the mouth of the Channel, near the Sole banks, between Cape Clear and Ushant, have been already mentioned as probably representing the mouths of the rivers of the Irish and English Channels, which seem to have entered the Atlantic Ocean not far from each other. But Professor Hull perceives something more than this. For him these two rivers in early Pleistocene time were draining a highland plateau some 6,000 feet above the level of the sea. This, after all, is moderate, being only half of what Professor Spencer requires. The western termination of this elevated plateau was a magnificent 'escarpment,' which, if viewed from the outer ocean, would be found to be 'terrestrial,' not oceanic, in origin. When the two rivers approached the edge of this escarpment they entered the ocean in a series of grand cascades or rapids, which are now represented by the submerged cañons that seam the great suboceanic slopes.

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[1] Trans. Victoria Institute, 1898.

[2] At the meeting held in the Map Room of the Royal Geographical Society (Jan. 27) for the purpose of hearing and discussing Professor Hull's latest paper on this subject, some of the speakers were disposed to criticize his tracing of the old river-courses cut in the continental shelf—e.g. the River of the English Channel. But this really is a very minor matter, and altogether fails to touch his principal contention. Most persons who have paid attention to the physical geography, past and present, of these Islands agree that the area of the English Channel was at one time sufficiently elevated as to have been within the influence of meteoric erosion: a difference of 100 fathoms would more than effect this. Thus we may readily allow Professor Hull his rivers of the English and St. George's Channels, even if we are disposed to criticize the exact course they may have taken. But the deep sculpturing which he claims to have been effected in the *suboceanic continental slope* (the 'escarpment' of Professor Hull) by these same rivers involves considerations which would land us in serious difficulties. If the 'edge' or angle of the slope was at one time raised 1,000 fathoms above the level of the sea, instead of being 100 fathoms below it as at present, in that case the region now occupied by the English Channel must have been raised to that extent or more, unless the River of the English Channel was endowed with the faculty of running up hill. Suppose we take the period as Pliocene: this means an upland of 6,000 or 7,000 feet above sea-level in the vicinity of the region now occupied by the Straits of Dover, whilst some sixty miles to the northwards the Crags were being deposited in a shallow sea, whose area is now partly occupied by the Suffolk coast. Truly, in this case we should require another 'escarpment' facing the area now

I certainly demur to the view that the suboceanic continental slope represents an 'escarpment' in the geological sense;[1] but it must be admitted that the soundings beyond the edge of the platform, both at the Sole banks and elsewhere in certain localities round the Bay of Biscay, are curious and perplexing, whether the cañon theory be applicable or not. Thus, there are two tongues of deep water which appear to indent the suboceanic slope in connection with the mouth of one of the Channel rivers. This feature is interpreted by Professor Hull as a river-course with two branches enclosing a kind of island between them, and similar cases occur in connection with supposed cañons elsewhere. His drawings are very effective, but the steepness of the supposed gorges is greatly accentuated by the difference between the vertical and horizontal scales. As regards geological age Professor Hull refers the British platform like the American continental shelf to the Mio-Pliocene period. But he refers his 'grand escarpment' to the succeeding early Pleistocene or Glacial stage, when, according to his views, the great continental uplift took place. These conceptions as to the sudden uprise of the sea bed, so as to form an escarpment at that comparatively late date, are certainly opposed to the generalizations of Mr. Jukes-Browne. That author, in "The Building of the British Isles," continuously reduces the land area and increases the sea area from the Oligocene

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occupied by the North Sea to meet the difficulty. If we take the period as Pleistocene we are no better off. To enable the River of St. George's Channel to surmount the edge of the 'escarpment' we must raise the drainage area behind, and this it would be difficult to effect without converting the Irish Sea into an inland lake over 6,000 feet above sea-level.

[1] This point is now conceded by Prof. Hull (see Geol. Mag., March, 1899, p. 132).

period down to the Pleistocene, when the coastline of the British platform is represented as coinciding with the contour of 80 fathoms.

The strongest case for a cañon is undoubtedly the Fosse de Cap Breton at the head of the Gulf of Gascony, the leading bathymetrical features of which I have already briefly described. Here, as we know, the 100-fathom platform is cut through to a depth of 600 fathoms; and if this be due to ordinary river erosion consequent on emergence, it implies an elevation of between 3,000 and 4,000 feet at this particular place. It is singular that this well-marked 'fosse' should occur almost exactly in the angle formed by the French and Spanish shores of the Bay of Biscay. If it be really due to river action it may represent the effects of the accumulated waters draining the northern slopes of the Pyrenees. It must not be forgotten, however, that the south-west of France represents a Tertiary basin, and that throughout the greater part of Tertiary time there must have been something like a connection between the Bay of Biscay and the Golfe du Lion, which has obviously formed the principal communication between the Mediterranean and the Atlantic. The difficulty is further complicated by the fact that both the Fosse de Cap Breton and its supposed prolongation opposite Bilbao are within the tectonic influences of the Pyreneo-Cantabrian chain, and therefore belong to a region of exceptional dynamic activity.

CONCLUSION.

This paper has already exceeded the intended length, and yet without my having completed the work originally contemplated. It is not altogether an easy task to alternate hydrographical facts with geological theories. Although not holding any particular theory myself, I am somewhat inclined to the belief that the larger features of the earth's crust, and particularly the ocean basins, may have been permanent within certain limits. The flanks of these great depressions are more correctly described as slopes rather than as escarpments; and these slopes are probably due to ancient and deep-seated tectonic causes, active in some places and quiescent for a time in others. The eastern margin of the North Atlantic basin presents, as regards activity of motion in the present day, a marked contrast to the eastern margin of the Pacific, where the mobile condition of the suboceanic slope, off the coasts of South America, is well known. This comparative stability, however, may not always have prevailed. Indeed, we may feel pretty sure that movements have occurred along this line throughout geological time, altogether independent of local eruptions of basalt, etc.

If I might venture to sum up the results of the views suggested in this paper, they would appear somewhat as follows:—

1. The true boundary of the North Atlantic basin on this side is not to be sought in the existing coastlines, but in the submerged slope which lies beyond the edge of the submerged platform.

2. The edge of the submerged platform appears to range from about 80 to 250 fathoms, the most notable deviation from the usual depth occurring in connection with the irregular bulge of submerged

land bordering the Porcupine bank, off the west of Ireland. But the 100-fathom line is found for long distances to coincide fairly well with that edge, beyond which the suboceanic slope plunges, sometimes gradually, sometimes sharply, into abyssal depths.

3. The suboceanic slope may be traced as a distinct feature, though better defined in some places than in others, with a general north-north-easterly trend, as far as off the north-west of Spitzbergen, where the trend becomes easterly in face of the North Polar ocean.

4. The suboceanic slope is to be regarded as the true limit between the continental area and the oceanic area, and the terrigenous deposits appear, throughout geological time, to have been confined to the region which lies within, i.e. to the eastward of, this line.

5. The great tectonic movements have been especially powerful in alignment with the suboceanic continental slope at different periods of the world's history; and these movements have produced extensive protuberances, which have yielded no inconsiderable portion of the sediments deposited in the corresponding geosynclinal hollows, thus constituting some of the great terrigenous formations. The extensive development of old crystalline rocks in the countries which border the North Atlantic probably represent portions of these old protuberances.

6. Although the line dividing the continental from the oceanic area is fairly well defined throughout the region under consideration, it is one of unequal strength, and appears to fail or to be deeply deflected in certain places. Commencing on the north, the first great embayment is represented by the mouth of the Barents Sea. Here the coastline with its old crystalline rocks, of which there are said to be considerable traces in the west of Spitzbergen, fails us until we get to Norway. Similarly there is a great gap between Norway and Scotland, the intervening area being represented by the mouth of the North Sea. Both these embayments are occupied by shallow seas and their connections, and they may be regarded as belonging to the continental area and to share its vicissitudes. Yet it is probable that throughout a part, at least, of geological time they have been the gateways whereby the waters of the ocean communicated with the various seas, where deposits since elevated into dry land have from time to time been formed.

Omitting the mouth of the English Channel, which possibly has a different origin, the next great embayment is the Bay of Biscay, and this differs from the two previously mentioned by its great depth. This seems to represent the gateway, whereby the waters of the ocean communicated with the Mediterranean, though in the present day the head of the gulf has been filled up by the Tertiary deposits, which constitute so large a portion of the south-west of France. Moreover, this area is complicated by the great tectonic movements in connection with the Pyreneo-Cantabrian chain. The gut of Gibraltar is probably a more recent feature, and may in part be due to meteoric erosion at a time when the land was higher. This also may have been the case with the Fosse de Cap Breton.

7. In addition to the inferences stated under 6, it is obvious that extensive basaltic eruptions in certain portions of the North Atlantic depression have interfered with the regularity of the suboceanic continental slope. These are associated with terrigenous rocks on the continental side of the slope, but apparently not so on the oceanic side. Of the former case Franz Josef Land and the Hebrides supply noteworthy instances.

8. With respect to the amount of elevation undergone at various periods along the eastern margin of the North Atlantic basin, there are no very certain data. Speculation on this point should be confined within reasonable limits, and we ought to be content with the minimum divergence from present-day conditions which is required to account for the most obvious facts. Subsequent to the commencement of the Tertiary period, local changes to the extent of 500 fathoms would still leave the great depths unaffected, whilst there is no reason to believe that any changes to this extent have occurred in Pleistocene times. In Fig. 1 it will be seen that special prominence has been given to the 500-fathom line.

II.—On the Families of Sauropodous Dinosauria.[1]

By Professor O. C. Marsh, Ph.D., LL.D.

THE subclass Dinosauria, as known to-day, I have divided into three orders: the Theropoda, or carnivorous forms; the Sauropoda, or herbivorous quadrupedal forms; and the Predentata, also herbivorous, and including several suborders, namely, the Stegosauria and Ceratopsia, both quadrupedal, and the Ornithopoda, containing bipedal bird-like reptiles.[2]

The principal characters of the order Sauropoda, here discussed, may be briefly stated as follows:—

Order SAUROPODA.

External nares at top of skull; premaxillary bones with teeth; crowns of teeth rugose, and more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; braincase ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs co-ossified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own sacral rib, or transverse process; no diapophyses on sacral vertebræ; neural canal much expanded in sacrum; first caudal vertebra biconvex; anterior caudals procœlian. Sternal bones parial; sternal ribs ossified. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no post-pubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; astragalus and calcaneum not fitted to end of tibia; feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified; locomotion quadrupedal.

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[1] Abstract of communication made to Section D, British Association for the Advancement of Science, Bristol Meeting, September 12, 1898.

[2] The Dinosaurs of North America. Sixteenth Annual Report, U.S. Geological Survey. 84 plates. Washington, 1896.

(1) Family Atlantosauridæ. A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded; coracoid quadrilateral. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ short, with lateral cavities; remaining caudals solid; chevrons single.

Genera *Atlantosaurus*, *Apatosaurus*, *Brontosaurus* include the largest known land animals. Jurassic, North America.

(2) Family Diplodocidæ. External nares at apex of skull; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Scapula with shaft somewhat enlarged at summit. Ischia with shaft expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow, with three co-ossified vertebræ. Anterior caudal vertebræ procœlian, with sides deeply excavated, and chevrons single; median caudals excavated below, with chevrons double, having both anterior and posterior branches; distal caudals elongate, with rod-like chevrons.

Genera *Diplodocus* and *Barosaurus*. Jurassic, North America.

(3) Family Morosauridæ. External nares anterior; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front; teeth very large. Shaft of scapula expanded at distal end; coracoid suboval. Sacral vertebræ four in number, and nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid; chevrons single.

Genera *Morosaurus*, *Camarasaurus* (?) (Amphicœlias). Jurassic, North America and Europe.

(4) Family Pleurocœlidæ. Dentary bone constricted medially; teeth with crowns like those of *Diplodocus*. Cervical vertebræ elongate, centra hollow, with large lateral openings; sacral vertebræ solid; with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; median caudal vertebræ with neural arches on front half of centra. Ischia with compressed distal ends, and sides meeting on median line.

Genera *Pleurocœlus*, *Astrodon* (?). Jurassic, North America and Europe. Include the smallest known Sauropoda.

(5) Family Cardiodontidæ. Teeth of moderate size. Upper end of scapula expanded; humerus elongate; fore limbs nearly equalling hind limbs in length. Sacrum solid; ischia with wide distal ends, and sides meeting on median line. Caudal vertebræ biconcave; median caudals with double chevrons.

Genera *Cardiodon* (Cetiosaurus), *Bothriospondylus*, *Ornithopsis*, and *Pelorosaurus*. European, and probably all Jurassic.

(6) Family Titanosauridæ. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebræ biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. Cretaceous (?), India and Patagonia.

III.—THE BASE OF THE GAULT IN EASTERN ENGLAND.

By A. M. DAVIES, A.R.C.S., B.Sc., F.G.S.

IN a paper published in this Magazine in March, 1895,[1] Dr. J. W. Gregory, incidentally discussing the exact age of the base of the Gault Clay, wrote: "*Hoplites interruptus* seems restricted in [Eastern] England to the Folkestone area and the Red Chalk." Although some of his conclusions on that point were modified later,[2] the general statement quoted above, with the qualification indicated by the bracketed word 'Eastern,' does not seem to have been challenged. Having myself found *H. interruptus* at the base of the Gault at several places in Eastern England, I have been led to look up previous records, with the result that I am convinced that the zone of *H. interruptus* is represented in the lowest beds of the Gault Clay over a large part of that area.

Taking first the Gault outcrop south of the North Downs, the following table shows the localities from which this fossil has been recorded, in order from east to west, and the distances between them :—

LOCALITY.	AUTHORITIES.	NOTES.
Folkestone.	*Omnes passim.*	
19 miles.		
Leacon Hill, 2 miles S. of Charing.	Fitton, Trans. Geol. Soc., ser. II, vol. iv, p. 112.	'*Amm. dentatus.*' For locality see also T. R. Jones, GEOL. MAG., Dec. II, Vol. III (1876), p. 118.
17 miles.		
Aylesford and Maidstone district.	De Rance in Topley's "Weald Memoir."	
13 miles.		
St. John's Brickyard, between Sevenoaks and Otford.	A. M. D.	*H. splendens* also.
4½ miles.		
Westerham.	Fitton, loc. cit., p. 162.	'*Amm. dentatus*' in Gault Clay. Specimen in Geol. Soc. Museum.
9¾ miles.		
Battlebridge, near Merstham.	Whitaker & Hinde, Proc. Geol. Assoc., vol. xv, p. 114.	
9¼ miles.		
Westcott, near Dorking.	Leighton, Proc. Geol. Assoc., vol. xiii, p. 9.	At base of Gault.
20 miles.		
Wracclesham, near Farnham.	Monckton, ibid., p. 76.	In sandy beds, four or five feet below base of clay.
4 (?) miles.		
Railway cutting "near Alton."	Bristow & Whitaker, "Geology of parts of Berks and Hants": Mem. Geol. Surv., Sheet 12, p. 4.	*Acanthoceras mammillatum*, *Hoplites lautus*, and *H. tuberculatus* recorded also. All from Gault; no details.

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[1] "Fossils from Lower Greensand of Great Chart": GEOL. MAG., Dec. IV, Vol. II, p. 97.

[2] Ibid., pp. 187-9.

In all these cases, the fossils clearly came from either the actual base of the Gault, or from Gault Clay not far above Lower Greensand, except in the case of the last but one, and possibly the last. The gaps of 20 miles, without a record, simply indicate stretches of outcrop where exposures are few. The conclusion seems inevitable that along the outcrop from Folkestone, at least to Dorking, the lithological change from 'Lower Greensand' to 'Gault' represents a constant time-level, though farther west this may perhaps cease to be the case.

Let us next take the northern outcrop from Norfolk to Berkshire:

LOCALITY.	AUTHORITIES.	NOTES.
Hunstanton. 6½ miles.	Wiltshire, "Red Chalk of England," p. 17.	'*Amm. serratus*' in Red Chalk.
Ingoldsthorpe. 20 miles.	Fitton, loc. cit., p. 316.	In grey sandy clay. '*Amm. dentatus.*'
West Dereham. 19 miles.	Jukes-Browne & Hill, Quart. Journ. Geol. Soc., vol. xliii, p. 571.	
Upware. 7 miles.	Keeping, GEOL. MAG., Dec. I, Vol. V (1868), p. 272.	Base of Gault.
Between Landbeach and Cottenham. 9 miles.	Penning & Jukes-Browne, "Geology of the Neighbourhood of Cambridge": Mem. Geol. Surv., Sh. 51 (S.W. and N.W.), p. 19.	
Haslingfield. 19 miles.	Ibid., p. 17.	
Campton, near Shefford. 14 miles.	Price, "The Gault" (London, 1879), p. 29.	
Heath, N. of Leighton Buzzard. 19½ miles.	A. M. D.	Base of Gault. With *H. tuberculatus* and *Schlönbachia inflata*. (See below.)
Thame (brickfield between Railway Station and Thame Park). 14 miles.	A. M. D.	Base of Gault. (See below.)
Culham. 38 miles to Devizes.	Phillips, Quart. Journ. Geol. Soc., vol. xvi, p. 307.	Base of Gault. '*Amm. dentatus.*'

The specimens from Heath were found in Mr. Bushell's old pit, visited by the Geologists' Association in 1897[1] under the guidance of Mr. A. C. G. Cameron. As I understand that the pit will soon be closed over, it may be well to give a full list of fossils from it. These were in part collected by my wife on the visit of the Geologists' Association, partly by myself on a later occasion. All except the belemnites are phosphatized.

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[1] Proc. Geol. Assoc., vol. xv, p. 184.

Hoplites interruptus.
H. tuberculatus.
H. lautus (?) (a worn fragment).
Schlönbachia inflata.
Belemnites minimus (abundant).
Solarium.
Dentalium.
Inoceramus concentricus.
I. sulcatus.
Fish-scales.
Fish-coprolites.

The mixture of Upper and Lower Gault fossils is striking, but has been noted already for this district by Mr. Jukes-Browne[1] and also appears to exist in the Isle of Wight, where *S. inflata* occurs in the Gault Clay along with *H. interruptus*, as well as ranging through the Malm and Chert beds above.[2] I should, however, add that some thickness of Gault is exposed at Heath (at least fifteen feet, speaking from memory), and that owing to the large extent of slip no fossils could be obtained actually in place, so that some may have come from a higher zone than others.

At Thame the actual junction of Gault and 'Lower Greensand' (here probably of fresh-water origin) is not seen, but the two are dug in shallow pits not many yards apart. The fossils I obtained here were—.

Hoplites interruptus,
Belemnites minimus,

and the following Foraminifera:—

Cristellaria gibba, D'Orb.
C. subalata, Reuss.
C. gaultina, Berthelin.
Pulvinulina spinulifera (Reuss).

Another Gault-pit, a mile and a quarter farther west, where the Shillingford Road crosses the railway, is absolutely unfossiliferous, even foraminifera being unobtainable.

On the outlier at Long Crendon, 2¾ miles to the north-west, the base of the Gault is clearly exposed, but here I failed to find Ammonites, though foraminifera were plentiful.

In the 38 miles between Culham and Devizes, the Gault appears to be very unfossiliferous. When the Geologists' Association visited Faringdon in 1877, Mr. E. C. Davey published a catalogue[3] in order, as he states, "to vindicate the palæontological honour of Berkshire." He complained that "the Government Surveyors have not recorded a single specimen from either Gault or Upper Greensand," and "the late Professor Philips is equally silent." Nevertheless he was himself only able to give six genera (without species) for the Gault. There are therefore no data available, so far as I am aware, for fixing the exact age of the base of the Gault between Culham and the Devizes district.

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[1] "Handbook of Historical Geology," p. 412.

[2] Reid & Strahan, "Geology of the Isle of Wight."

[3] "Catalogue of Fossils from the Cretaceous Beds of Berkshire, in the Collection of E. C. Davey, F.G.S." (Wantage, 1877).

It is clear, however, that from the first coming-in of Gault Clay in Norfolk to its last fossiliferous exposure on the banks of the Thames, wherever its basal zone can be recognized it is that of *Hoplites interruptus.*

If we now turn to the underground distribution of the Gault in the area between the two outcrops we have been considering, we find that the Gault, taken as a whole, is continuous under the entire district so far as the evidence goes. It varies greatly in thickness, but if we plot out all the borings on a map and sketch out lines of equal thickness between them, we find that, in spite of many irregularities, these lines have a general N.W.–S.E. trend, and indicate a north-easterly thinning, which becomes strikingly manifest at Weeley, Stutton, and Harwich. As this north-easterly thinning is accompanied by disappearance of the Lower Greensand, it is due probably to overlap, and not to erosion of the Upper Gault like the northerly thinning along the outcrop. There is, therefore, an *a priori* probability that the lower zones of the Gault as we pass to the north-east first take on a shallow-water facies (which would be called 'Lower Greensand') and then are overlapped altogether. But so many different circumstances combine in affecting the thickness of a deposit that it is not safe to base any definite conclusions on it alone. From only one of the borings in this area have fossils been recorded which could help in the determination of the basal zone of the Gault, and that is the Richmond boring. Dr. Gregory has discussed[1] the evidence from this boring, and concludes that it is in favour of the absence of the *H. interruptus* zone.

After pointing out that *H. splendens* occurred both at 1,100 and at 1,128 feet depth, he says: "This species ranges from the 4th to the 7th zone of the Gault. If we make the somewhat improbable assumption that this [the lower] specimen came from the very lowest possible point at which it could have occurred, then zones 1–3 are reduced to a thickness of only 13 feet. Thus, either the three basal zones are proportionally much thinner at Richmond than they are at Folkestone, or else one or more of them is there absent. The latter view appears the more probable."

I am afraid this argument will not stand a close examination. It is true that in the Weald Memoir the range of *H. splendens* is given as zones 4–9 (not 7), but Price records it from his zones 2–8,[2] answering to De Rance's 3–8. Combining the two, we find the maximum range to be through about 27 feet, starting at 10 feet from the bottom. At Richmond the two specimens were 28 feet apart, and the lower one 13 feet from the bottom—a curiously close approximation to the Folkestone range. Moreover, *H. splendens* is not so restricted everywhere as at Folkestone. I have found it along with *H. interruptus* at St. John's, near Sevenoaks, and Mr. R. B. Newton has recorded it from the *interruptus*-zone of

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[1] Loc. cit., p. 101.

[2] Quart. Journ. Geol. Soc., vol. xxx, p. 342.

Okeford Fitzpaine, Dorset.[1] The proof which it was supposed to give of the absence of that zone at Richmond consequently falls to the ground.

In conclusion, I have to express my sincere thanks to Mr. G. C. Crick for his ever ready help to me in the identification of Cephalopods; to Mr. F. Chapman for identifying the foraminifera; and to Dr. Hinde for kindly sending me the fossils collected at Battlebridge to examine.

NOTICES OF MEMOIRS.

NOTES ON ROCKALL ISLAND AND BANK. With an Account of the Petrology of Rockall, and of its Winds, Currents, etc.; with Reports on the Ornithology, the Invertebrate Fauna of the Bank, and on its previous History. Transactions of the Royal Irish Academy, vol. xxxi (1897), pt. 3, pp. 39–98, with plates ix–xiv.

THIS memoir contains the results of an exploration carried on under the direction of the Rev. W. Spotswood Green, of the Irish Fisheries Board, with the assistance of Mr. Harvie Brown, Mr. R. M. Barrington, and a committee of the Royal Irish Academy. In June, 1896, the s.s. "Granuaile," of the Congested Districts Board, made two visits to the Rockall Bank, but none of the party of naturalists on board of her were able to effect a landing upon Rockall itself, though some interesting sketches and photographs were made of it, and valuable collections obtained from the surrounding seas.

The Rockall Bank is situated in the Mid-Atlantic, and it is separated from the plateau on which the British Islands stand by seas having a depth of from 1,300 to 1,600 fathoms. The bank is 150 miles long from N.E. to S.W., by about 50 miles wide, within the 200-fathom line, and about half that extent within the 100-fathom line; it is resorted to by fishing-craft at certain seasons, but the amount of fishing carried on there has not been so great as was at one time anticipated.

Rockall itself, which is situated in lat. 57° 36′ N., long. 13° 42′ W., is said by Captain Basil Hall to be "the most isolated speck of rock in the world." It is 240 miles distant from the Irish coast, 290 miles away from the nearest point of Scotland, and 170 miles from St. Kilda. It is only about 250 feet in circumference at its base, and about 70 feet in height. At a radius of 2½ miles from the rock the depths are from 40 to 70 fathoms, but within this area two other small rocks rise nearly to the surface of the sea. 'Haslewood Rock' is a small half-tide detached rock, bearing N.E. by N. 1½ cables from Rockall, and 'Helen's Reef' (so called from a vessel that was wrecked upon it) is 1¾ miles E. by S. from Rockall, and has about six feet of water upon it at low-water.

It has sometimes been suggested that Rockall might form an invaluable position to be utilized for a lighthouse or a meteorological station. But minute as it is in size, and exposed as it is to the full swell of the Atlantic, which rises and falls there more than 12 feet in the calmest weather, such use of the rock appears to be out of the question. Indeed, fishermen and sailors from men-of-war have only occasionally effected a landing upon it, under the most favourable conditions, with the greatest difficulty. The rock lies out of any of the usual tracks followed by steamships and sailing vessels in crossing the Atlantic. At a distance it appears, with its dark-coloured base and top whitened with the dung of innumerable sea-fowl, so like a ship under full sail, that in war-time the captains of men-of-war are said to have been frequently deceived by it.

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[1] GEOL. MAG., Dec. IV, Vol. III (1896), p. 200.

Although no landing was effected during the recent investigation of Rockall, the exploring party managed to secure a number of interesting drawings and photographs of the rock. The Rev. W. S. Green describes the general character of the mass in the following words:—"The east face seemed like a great slab of gray granitoid rock (and I was within 20 yards of it), with rectangular joints broken off at the north, so as to show the square edge of another slab, and this was in turn broken off, showing the face of a third." This granitoid mass "rests on a rock showing a kind of bedding or jointing (?), dipping about east, and at an angle of 30° or so."

So far as is known, no specimens have ever been obtained from this underlying mass on the west or south-west of the rock, and it is impossible to say whether it consists of sedimentary materials, or stratified tuffs, or of some fissile igneous rock.

Of the overlying granitoid mass, however, the relations of which seem to strikingly resemble those of an intrusive sheet, the indefatigable exertions of Professor T. Rupert Jones have resulted in bringing together three specimens. These have been submitted to Professor Judd for examination in the Geological Laboratories of the Royal College of Science. One of these specimens was obtained by Basil Hall as long ago as the year 1810, when Rockall was visited by H.M.S. "Endymion"; the others were obtained by Commander Hoskyn and Captain Inskip respectively, during the visit of H.M.S. "Porcupine" to the rock in 1862. In each case the specimens were obtained by an active sailor, with a line attached to him, springing from a boat on to the rock, and, when he had secured fragments of it, throwing himself into the sea to be towed back to the boat.

Two of the specimens were found on microscopic examination to be distinctly granitic in structure, the quartz, felspar, and augite of which they are made up being allotriomorphic. Their structure, however, resembles that of the granite-porphyries rather than that of the true granites. The third specimen, while made up of the same minerals, is distinctly hypocrystalline, having the kind of groundmass which Rosenbusch distinguishes as 'hypidomorphic.' This variety, having a darker colour, as well as a finer texture, may not improbably form veins, or possibly inclusions, in the main mass; or it may belong to the edge of the intrusive sheet. All the rocks are somewhat drusy or miarolitic in structure.

Detailed microscopical examination shows that the material of

Rockall is really of a very unique and interesting character. The rock consists of three minerals—a soda-augite (ægirine and acmite), quartz, and albite. Accessory minerals, other than magnetite and apatite, appear to be very rare in it. The proportion of these ingredients is somewhat different in the several examples of the rock, the darker-coloured variety containing more of the soda-augites.

The order of crystallization of the minerals of the rock is easily determined. The soda-augite (ægirine and acmite) was the first to separate, the centres of the crystals being grass-green ægirine, and the peripheral portion brown acmite, each mineral exhibiting its characteristic pleochroism. After the augite, albite separated, and the quartz crystallized out last.

Apatite needles are found enclosed in all the minerals of the rock, and among the secondary minerals of the rock are magnetite, quartz, arfvedsonite, and a blue soda-amphibole.

The specific gravities of different specimens determined by Mr. H. S. Hinton, F.G.S., were found to vary from 2·71 to 2·94.

An analysis of the rock of the highest specific gravity and darkest colour, which was made by Mr. C. J. S. Makins, under the superintendence of Professor W. A. Tilden, gave the following result:—

Silica	73·60
Alumina	4·70
Ferric Oxide	13·10
Manganese Oxide	·93
Nickel Oxide	·06
Magnesia	·11
Lime	·37
Soda	6·96
Potash	minute trace
Phosphoric Acid	traces
	99·83

This analysis shows the mineralogical constitution of the rock to be as follows:—

Ægirine and Acmite	39 per cent.
Quartz	38 ,,
Albite	23 ,,
(With a little anorthite.)	

The soda-augite (ægirine and acmite) appear to have a very similar composition to that of the rocks of the Christiania district described by Brögger, while the bulk analysis of the rock resembles that of some of the quartz ceratophyres and some of the quartz-pantellerites of Foerstner.

The nearest analogues of the rock of Rockall are to be found among the grorudites of Brögger (quartz-tinguaite of Rosenbusch). Professor Brögger, who has examined a section of the rock sent to him, agrees that the rock is similar to his grorudites in mineral composition, but he demurs to it being included under his name on account of the differences in structure. On the other hand, the rock of Rockall is shown to differ from the Natron-granites, some of which it resembles in structure, by its high proportion of augite.

Under these circumstances it is proposed to give to the material o Rockall a distinctive name and to call it 'Rockallite.'

Rockallite is defined as a rock having the structure of th 'granite-porphyries' but belonging to the extreme variety o the soda-bearing acid rocks. It is an ægirine-quartz-albite rock intermediate in structure and composition between the soda-granite on the one hand and the grorudites on the other, and presenting point of analogy with some soda-ceratophyres. Among lavas or effusiv rocks, rockallite is probably represented by some quartz-pantellerites

With respect to the age and relations of the rock forming th singular isolated mass of Rockall, the materials for arriving a a judgment must be admitted to be very small. If the rock, on whic the igneous mass lies and over which it appears to have been thrust could be examined, and especially if this were shown to be a stratifie rock with fossils, the evidence thus afforded would be of great value At present, however, we have nothing but general analogies to guid us. The nearest resemblance to rockallite is found, as we have seen among the Post-Silurian dykes in the Christiania district so admirabl investigated by Professor Brögger; and it may be that in Rockal we have a similar intrusive mass of the same period that ha escaped destruction by denudation. But it must be remembere that among the Tertiary rocks of the Western Isles of Scotland, i St. Kilda (which is the nearest land to Rockall), in Skye, Ardna-murchan, Mull, and Arran, we have granites and granite-porphyrie containing soda-augites and soda-amphiboles. Some rocks, indeed approaching in character to rockallite, occur among the Tertiar eruptives, and it is, therefore, by no means impossible that rockallit may belong to the same recent period.

In another division of the memoir before us, Professor Grenvill A. J. Cole describes the rock-specimens dredged on the Rockal Bank. These all show a remarkable uniformity of character, as i the original source of the material had been true local rock-masse rather than any ice-drift.

The great mass of the specimens appears to be basalt of th ordinary type. Some of these appear to be destitute of olivin and approximate to augite andesite or basalt andesite. Some a vesicular; others are more or less glassy in texture, and exhib flow-structures. An andesitic pumice and a scoriaceous andesit "well removed from the extreme basaltic types," were also foun With these igneous rocks was found one example of a fine-graine grey argillaceous and slightly micaceous sandstone, strikingl resembling the Ordovician sandstones in the altered strata o County Down.

Among specimens supplied by Mr. Cordeaux of Grimsby, and obtained by fishermen entangled in their lines when fishing on the Rockall Bank, are many basalts; also one specimen of an ordinary red granite with micro-pegmatite and a red sandstone, very similar to the Torridonian rocks.

Mr. R. H. Scott supplies to the memoir an account, illustrated by sketch charts, of the winds and currents in the district in which

Rockall occurs. The sources of information for these charts are the logs of Her Majesty's ships since 1830 and of vessels in the Mercantile Marine since 1854.

Mr. H. N. Dickson, of the Chemical Laboratory, University Museum, Oxford, gives the results of a series of analyses by which the degree of salinity of a number of samples of sea-water collected off Rockall was determined.

The memoir concludes with a series of Reports on the Natural History of Rockall and the surrounding seas. That on the Ornithology is by Mr. J. A. Harvie Brown; that on the Mollusca by Mr. A. R. Nichols, of the Science and Art Museum, Dublin; that on the Crustacea by Mr. W. T. Calman, B.Sc., and Professor E. P. Wright; that on the Chætopoda by Professor M'Intosh; that on the Echinodermata by Mr. W. P. Sladen; that on the Polyzoa by Miss L. R. Thornelly; and that on the Sponges by Professor R. von Lendenfeld.

Professor T. Rupert Jones, who has been untiring in his efforts to obtain new light on this most interesting locality, contributes a very valuable sketch of the previous history of Rockall, and a general epitome of all that has hitherto been published concerning it.

The memoir is well illustrated by three coloured drawings of Rockall from sketches by the Rev. W. S. Green; six photographs of the rock taken from different directions; a beautiful plate, showing the characters of the two types of 'rockallite' as seen in thin slices under the microscope, drawn by the skilful hand of Mrs. Cole; and twelve charts showing the directions of currents around Rockall during every month of the year.

The Royal Irish Academy is to be congratulated upon their spirited attempt to gain new light upon this interesting locality, and no less so on the manner in which the results achieved have been presented to the public in their 'Transactions.'

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES. "THE GEOLOGY OF THE ISLE OF PURBECK AND WEYMOUTH." By AUBREY STRAHAN, M.A., F.G.S. 8vo: pp. xi and 278; 5 plates from photographs, 2 folding plates, and 183 other illustrations in the text; map and 3 plates of sections at the end of the book. (London, 1898. Price 10*s.* 6*d.*)

IN his preface the Director-General of the Geological Survey remarks that "when the revision of the Geological Survey maps of the Isle of Wight was completed in 1888, it was deemed advisable to continue the work into the adjacent parts of Dorset. The task of resurveying the classic Isle of Purbeck and the region round Weymouth was entrusted to Mr. A. Strahan, who had mapped the Secondary formations of the Isle of Wight. In two years the field-work was finished as far as the top of the Chalk, and the mapping of the Tertiary deposits was subsequently completed by Mr. C. Reid."

Quite recently also five new sheets of this district, based upon a new series of Ordnance Survey maps, have been issued coloured geologically; and thus both the topography and geology of the district have been rectified and brought up to date. Manuscript copies of the original six-inch working maps are to be seen at the Museum of Practical Geology.

So far as the Jurassic portion of this work is concerned, it is to a considerable extent a reissue of that part of Mr. H. B. Woodward's memoir on the Middle and Upper Jurassic rocks of England (vol. v of the "Jurassic Rocks of Britain") relating to this district. Mr. Woodward's work was reviewed in the GEOLOGICAL MAGAZINE for 1896,[1] when we had occasion to comment unfavourably on the printing of some of the illustrations. Mr. Strahan has been more fortunate in having his memoir on the Isle of Purbeck better treated by the Stationery Office, so that the same figures of Jurassic fossils, which were so indistinctly printed in Mr. Woodward's memoir, come out much better in the Isle of Purbeck memoir, and this remark also applies to other illustrations repeated from Mr. Woodward's book. The new illustrations in Mr. Strahan's work (many of them being prints from photogravures) and the folding plates with coloured sections are exceedingly good. But, then, we must bear in mind that the price of this memoir, containing 278 pages, is 10*s.* 6*d.*, as against 7*s.* 6*d.* for vol. v of the "Jurassic Rocks of Britain," with its 449 pages.

We quite agree with the author that the district under consideration includes a length of coast which is hardly surpassed in interest in any other part of England. This interest may be said to culminate in the various coves, etc., about Lulworth, "which furnish an example of coast erosion that cannot easily be matched elsewhere." Stair Hole and Lulworth Cove are illustrated by the frontispiece, which has been reproduced from a photograph by Mr. Mason Good. Geologists are to be congratulated that this piece of coast is dissected by the sea in such a manner as to display stratigraphical features of the utmost importance—Alpine sections, one might almost say, in miniature. A few æons further back in time the progress of erosion would not have been sufficiently advanced to show these things well: a few æons later, if there are no material alterations in the level, and most of the phenomena in connection with the Isle of Purbeck disturbance at Lulworth will have disappeared, whilst the sea will merely wash cliffs of chalk having a dip of a few degrees to the northwards.

Under the heading of Purbeck Beds a considerable amount of fresh matter is introduced, though the chapter on Organic Remains is mainly derived from Mr. Woodward's memoir, with the same figures of fossils somewhat better printed. A similar remark applies also to such cuts as the diagram-section of part of Stair Hole, the silicified mass of Purbeck wood at Portisham, and others.

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[1] Dec. IV, Vol. III, p. 129.

The author is considerably exercised as to the question on what horizon the boundary should be drawn between the Jurassic and Cretaceous systems. "Without attempting," says the Director-General, "to decide this stratigraphical question in what is intended to be a local memoir, Mr. Strahan has laid stress on the classification which, though local, represents most naturally the relations of the rock-groups to each other in the South of England." We perceive that, whilst the base of the Purbecks is entirely distinct from the underlying Portland Beds, there is a difficulty in separating the former from the Wealden Series, whether palæontologically or stratigraphically; moreover, in this area the Wealden folds with the Jurassics. On the other hand, as fresh-water conditions were continued, no matter what the period may have been, the Wealden waters had no chance of receiving any accession of the neighbouring marine fauna, which in other regions was already assuming a Cretaceous type. Although there may be a difficulty in separating them, yet a very marked difference exists between the Lower and Middle Purbecks and the Wealden taken as a whole. The Purbecks consist largely of calcareous beds, and the area was liable to sudden incursions of the sea, which restored for a time a semi-marine fauna: the Wealden, on the contrary, is very poor in calcareous matter, and the deposits are more essentially fluviatile.

Mr. Strahan expresses his views in the following table (p. 76):—

Formations, South of England.	Conditions of Deposition.	Affinities.	Equivalents in the North of England.
Chalk. Upper Greensand and Gault.	Wholly marine.	Cretaceous.	Chalk. Red Chalk and Carstone.
Break.	—		*Break.*
Lower Greensand.	Wholly marine.	Cretaceous.	Tealby Series and Spilsby Sandstone; a stratigraphically continuous series of marine deposits with Oolitic affinities in the lower part.
Palæontological break due to sudden change of conditions.			
Wealden. Purbeck.	Estuarine marine alternating with and passing down into fresh-water and terrestrial.	Oolitic as relates to the plants, reptiles, & marine molluscs.	
Palæontological break due to sudden change of conditions.	—	—	*Break.*
Portlandian. Kimmeridgian, etc.	Wholly marine.	Oolitic.	Kimmeridgian, etc.

Of the many curious features which the Lower Purbeck present that of 'brecciation' has caused not a little difference of opinion Mr. Strahan is inclined to support the view propounded by the Rev. O. Fisher, that the fracturing of the 'broken beds' was du to their having been deposited over a mass of decaying trees an mosses and having subsequently fallen in. Plate iii gives a goo representation of the 'broken beds' near Lulworth, and may als be taken generally as a favourable specimen of the application o photography to stratigraphical features.

The Wealden Beds in this area are not particularly interesting from a palæontological point of view, though at Worbarrow Bay their total thickness is stated to be 1,237 feet, the formation becoming thinner westwards. The Lower Greensand is exposed in three coast sections, viz., at Punfield Cove in Swanage Bay, in Worbarrow Bay, and in Mupe Bay, westward of which it thins out. As already determined in the "Geology of the Isle of Wight,' the author accepts Mr. Meyer's opinion that the Punfield Beds o the Isle of Purbeck are Lower Greensand; he states also that the subdivisions of the Isle of Wight, though greatly attenuated, are partly recognizable at Punfield, where the total thickness is 198 feet At Worbarrow Bay the section shows 136 feet, and the beds are less fossiliferous. Of the few inland exposures of Lower Greensand the Corfe Castle cutting alone exhibited any points of interest.

The Gault and Upper Greensand, owing to a change in the character of the former, are not to be separated within the district Like the rest of the Cretaceous rocks, the Gault and Greensand are thinner in Purbeck than in the Isle of Wight, but unlike the others they thicken again further west. Palæontologically, these strata are divided by Dr. Barrois into the zones of *Pecten asper* and *Ammonites inflatus*, but the lithology does not quite correspond with the zoning. At Worbarrow Bay this formation is 167 feet thick. A fine series of fossils appears to have been collected by Barrois from the Upper Greensand of Durdle and Lulworth.

The Chalk, being one of the most important formations within the area, is dealt with at considerable length, and the figures of fossils are rather more successful than has been the case in some of the previous memoirs. Dr. Barrois' palæontological zones of the Chalk of South Dorset are given in a table (p. 166), and on the following page Mr. Strahan gives us his latest views on the subdivisions of the Chalk as displayed in Ballard Cliff:—

		Ft.	in
UPPER CHALK.	Chalk with flints		
	Massive but somewhat lumpy chalk, without flints	20	
	Chalk Rock: a layer of very hard green-coated nodules ...	0	
MIDDLE CHALK.	Hard, rough, and lumpy chalk	6	
	Smooth, thick-bedded chalk, with partings of marl	90	
	Melbourne Rock; rough, nodular, and flaky chalk, with sparry joints	6	

			Ft.	in.
Lower Chalk.	Zone of *Belemnitella plena.*	Smooth chalk with conchoidal fracture and five partings of pale-blue marl ...	4	0
		Smooth chalk, passing into	2	0
		Fine marl	5	0
		Alternations of chalk and marl in bands of 1 to 2 feet in thickness: an occasional line of green nodules, like those of the Chalk Rock. *Ammonites varians* occurs in the lower 22 feet, but not above	126	0
		Hard chalk-marl weathering into rhombs	6	0
		Very hard splintery chalk	1	4
		Sandy and glauconitic marl	0	10
		Chloritic marl; glauconitic sand with rolled casts of *Ammonites*, *Nautili*, and *Exogyræ*, the last apparently indigenous	4	0

The westward attenuation of the Chalk is a noteworthy feature, as shown in the following table (p. 164):—

	Ballard Point.	Worbarrow, Lulworth, and White Nethe.	Black Down and westwards.
	ft.	ft.	ft.
Upper Chalk.	1,049	956	300-500[1]
Middle Chalk.	102	113-90	100-150
Lower Chalk.	149	114-104	

The fine features presented by the Chalk in the coast sections are well illustrated, including the classical section of the Isle of Purbeck fault on Ballard Cliff. These will be more appropriately noticed under the heading "Disturbances and Faults."

The full description of the Tertiary strata of the Hampshire Basin is reserved for another memoir, but a few notes on occurrences in this district are given, and these have been partly furnished by Mr. C. Reid. Bearing in mind that the most important industry of the northern half of the Isle of Purbeck is especially connected with the Bagshot Beds, which cover nearly half the area of the map, plate viii, any evidence as to their physical history cannot fail to be of interest. Westwards they are said to become very gravelly, and they have been found to cut through the London Clay so as to rest directly on the Chalk. These gravels may be distinguished from those of the Reading Beds by their containing, in addition to flint and chert, so much quartz and subangular Palæozoic rocks "as to make the fine-screened material look like a Cornish beach." The history of the outliers on Bincombe Down and on Blackdown, near Portisham, is very remarkable; and Mr. Strahan considers that the Bagshots on the former hill have been partly affected by the Ridgway fault "tilting up the south side of the Bincombe outlier, but leaving the northern half horizontal." Formerly these outliers were regarded as Reading Beds by the Geological Survey, and as Plateau gravel by Prestwich.

The subject of Pleistocene and Recent deposits also comes in for a fair share of notice; and here the author, *apropos* of the gravels of Portland Island, is led to take exception to the "interesting but erroneous speculation of Prestwich as to the age of the great topographical features of the district." The Broadway anticline, for instance, was of earlier age than supposed by Prestwich, "for its crest was planed off before the Upper Greensand was deposited." Of course, no work on the Weymouth district would be complete without a dissertation on the Chesil Beach, speculations as to the origin of which have given rise, he says, to a voluminous literature. To us it always seemed that the papers written by Sir John Coode in 1853 are by far the most valuable contributions to the subject. But the suggestion of the possible derivation of the quartzites and other far-travelled stones of doubtful origin from the destruction of the Plateau gravels of the more immediate district is one worthy of attention.

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[1] A variable thickness of Chalk is missing here.

Probably the most important part of this memoir is that dealing with faults and disturbances. Ever since the days of Webster and Sir Henry Englefield, in the early years of this century, the coast-sections of East Dorset, in continuation of those of the Isle of Wight, have attracted the attention alike of artists and stratigraphists. We are favoured with a new interpretation of the origin of the phenomena which are so conspicuously displayed in Ballard Cliff, where the Isle of Purbeck fault first comes under notice (see plate iv). The same explanation is also held applicable further westwards, viz., the horizontal thrust movement, whereby the Chalk has been ruptured and pushed over itself, in a manner not unlike that displayed by the thrust-planes of the North-West Highlands.

Evidence is also adduced to show that the several disturbances are referable to different periods. The *post-Cretaceous* movements are thought to indicate three steps—

1. Between Chalk and Eocene.
2. Between Lower and Middle Eocene.
3. Miocene and early Pliocene.

Of course, it goes without saying that the denudation consequent on the upheaval of the Chalk must have been progressing for ages before any Eocene beds were laid down in this part of the world, since Chalk-flints had been churned into pebbles on many a shingle bank as the waste went on, and these same pebbles form no inconsiderable portion of the Lower Tertiaries all over the South of England. The movements between Lower and Middle Eocene seem to be more special to their district. Then came the folding of the Miocene age, to which the bulk of the phenomena may be ascribed. The *pre-Cretaceous*, or, as Mr. Strahan calls them, the *intra-Cretaceous*, movements, which do not affect the beds above the Gault-Greensand, have already been mentioned in connection with the Weymouth district.

Though the Isle of Purbeck fault intersects the cliff again west of Lulworth, its form is clearly shown in Ballard Point only. Nevertheless, this disturbance produces results equally interesting on the Lulworth coast, where a region of compression occurs, as shown more especially by the squeezing and contortion of the Purbeck beds on the east side of Lulworth Cove, at Stair Hole, and other places. Plate v gives a good illustration of crushed and inverted Chalk-with-flints in Man O' War Cove. Here, the author says, we must conclude that the Middle and Lower Chalk, the Upper Greensand and Gault, and the Wealden and Purbeck Beds have suffered compression to the amount of one-fourth their original thickness. The other disturbances of post-Cretaceous age, and more especially the Ridgway fault, come in for their fair share of notice; whilst the remarkable phenomena observed in the Ridgway cutting, where Oxford Clay appears in the most unexpected manner, are duly discussed.

As regards illustrations for these important features, Mr. Strahan reintroduces his previously published map showing the intra-Cretaceous and post-Cretaceous disturbances, together with his previously published sections across the Purbeck and Ridgway faults. Three folding plates of sections, coloured geologically, further serve to display the marvels of the coast of East Dorset. These are drawn along or transverse to the coast by Mr. Strahan, and reduced from the original drawing by Mr. Gilbert Williams; the scale adopted is 12 inches to 1 mile, vertical and horizontal. It would be interesting to make a coasting voyage in order to compare these sections with Webster's bold drawings in Sir H. Englefield's work.

Chapters on physical and economic geology conclude this memoir, which is, moreover, provided with an exhaustive bibliography of some 25 pages on the "Geology, Mineralogy, and Palæontology of Dorset," the joint work of the author and Mr. Whitaker. The copious literature proves the interest which has been taken in this part of the world, and there can be no doubt that the volume under consideration is a most valuable addition to the general stock. Apart also from its value in a scientific sense, and as an indispensable addition to the library of all who take an interest in Dorset geology, it is more creditable to the Stationery Office than many of the memoirs which have been published by the Geological Survey.

II.—On Jurassic, Neocomian, and Gault Boulders found in Denmark. By Ethel G. Skeat and Victor Madsen. Large 8vo; pp. 213, with 8 plates of fossils and map. (Copenhagen: Reitzel, 1898.)

THIS work relates to the investigation of the fossil contents of a number of boulders of Mesozoic rocks, which are found associated with boulders of crystalline rocks in various parts of Jutland and the adjacent islands. The authors acknowledge the assistance they have received from various quarters; the material having been placed at their disposal by the General Direction of the Danish Geological Survey and other departments in Copenhagen. Their work was also greatly facilitated by assistance and advice from Professor Zittel at Munich; and facilities were afforded for comparing the various species with type-specimens in several museums throughout England, France, and Switzerland.

In additon to the introduction the work consists of two parts: (1) a description of the boulders themselves and the conclusions arrived at as to their age and origin; (2) a palæontological part, consisting of notes and descriptions of the principal species contained in the boulders. Throughout the work great care has been taken to exhibit the ranges both in time and space of the several species, mostly lamellibranchs, on which the identification of the age of the boulders is based.

The oldest Mesozoic rock of which evidence exists is represented by boulders of varying materials, in which the shells are both fresh and brackish water forms, unfortunately but ill preserved. These are regarded as having been derived from Rhætic-Lias beds, which are not yet known. All three stages of the Lias are represented, one boulder from the *Jamesoni*-zone being quite a little museum in itself. These Lias boulders are found principally on the islands and on the east side of Jutland. They are regarded as having been derived from the eastward; and the same direction is also claimed for the one Callovian boulder which contains a recognizable *Macrocephalites*. The authors do not fail to enlarge upon the wide extent of this well-known Jurassic horizon.

By far the most numerous collection of fossiliferous boulders occurs in the extreme north-west of Jutland, where a Kimeridge-Portland fauna of the Swindon and Hartwell type is well represented. It is considered that these have been derived from beds now concealed in the Skagerrack. The matrix is mostly a calcareous sandstone, more or less ferruginous; and we can easily believe that anything like typical Kimeridge Clay would hardly survive in a boulder deposit. The Upper Jurassic, as we know, is found in strips along the east coast of Sutherland and Cromarty, almost opposite Jutland on the other side of the North Sea, where the general assemblage of fossils is said to give evidence of littoral conditions. "Fragments of the grits and limestones of the Upper Oolite, containing their characteristic fossils, are by no means rare in the Boulder-clay of Elginshire, and have also been detected in Aberdeenshire and Caithness" (Judd, in Q.J.G.S., vol. xxix, p. 184). Thus, on both sides of the North Sea there are evidences of a considerable development of beds of Upper Oolite age; although, if the fossils from the Scotch beds have been correctly determined, they would indicate a somewhat lower Kimeridgian horizon than is shown in the boulders of north-west Jutland.

"Speaking generally, it may be said that the forms contained in the boulders are such as belong to the middle-European Jurassic province of Neumayr; and in the map accompanying his paper this Scaggerrack region is included in the north temperate zone of Jurassic times, as distinct from the boreal. The beds were laid down under rather similar but more uniform conditions than those of Boulogne, and indicate possibly an eastward continuation of the same shore-line." Somewhat similar conclusions are drawn from the examination of two Neocomian boulders.

In the second part the palæontology of the fossils found in the boulders is worked out with great care and discrimination, and, in fact, occupies the greater portion of the entire work. The formations are dealt with in order from Lias to Gault inclusive. Much pains is bestowed on the synonymy and distribution of each species recorded, whilst the list of the principal works referred to may serve to show the number of authors consulted. There are eight plates of fossils from photographs executed by E. Wilson, of Cambridge. This method is now largely employed on the Continent, and in cases like the present, where the point is identification rather than description, the results may be regarded as decidedly good. It is clear that some of the fossils cannot have been badly preserved. The Gasteropoda are the least satisfactory.

III.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), vol. ix, Reports A, F, I, L, M, R, S, for 1896. With plates and maps. 8vo. (Ottawa: Dawson, 1898.)

THIS volume comprises 816 pages and contains five maps and twenty plates. It begins, as usual, with a summary report, addressed to the Minister of the Interior, by the Director, Dr. George M. Dawson, C.M.G., F.R.S., dated 1st January, 1897, which sets forth the work done in the year 1896 at the Museum and head-quarters of the Survey in Ottawa, and that accomplished in the field, the latter including zoological and botanical as well as geological work.

Among other matters of greater or less importance relating to the Museum, the Director insists strongly on the advisability of a new Museum being built, which should be safer and more commodious than the present one, which he alleges to be, both by construction and situation, in grave danger of destruction by fire.

Dr. Dawson brings into prominence once more the essential functions of the Geological Survey by remarking that its chief work is "that of providing geological maps and reports of the several parts of the country, such as to be of value to the explorer, the miner, and others," and he adds that "the demand for information of the kind has been greater than ever before." He further states that the Geological Survey is the only organization under the Dominion Government which undertakes a general mapping of the country as a whole, work which has been carried on from the commencement of the Survey in 1843.

Very notable progress was made during the year 1896 "in the development of the mineral resources of Canada, both in the way of actual work and in attracting the attention and interest of capital. British Columbia has begun to evidence its value as a permanent producer of the precious metals, in a manner long foreseen by those who have paid attention to its geological structure and position. In Ontario, wherever the Huronian system is developed and has been examined, valuable mines, more particularly those of gold, are being discovered and opened up. In Nova Scotia renewed interest has been shown in gold-mining, and with improved machinery and methods the output is likely soon to be greatly increased. Other mineral industries throughout the country, whether already established or in course of development, share in a general appreciation."

After a short account of the explorations of the field corps, there follow some details of the work done in the Museum, in the sections devoted to chemistry and mineralogy by Dr. Hoffmann, to lithology by Mr. W. F. Ferrier, to mining and mineral statistics by Mr. E. D. Ingall, and to palæontology and zoology by Mr. J. F. Whiteaves, Dr. H. M. Ami, and Mr. L. M. Lambe. Under the last head Mr. Whiteaves' valuable contributions to Canadian palæontology are included, especially the well-known "Palæozoic Fossils." Dr. Ami applies his extensive knowledge of the fossils of the Palæozoic rocks of Canada to aid in the elucidation of stratigraphical problems relating to the geology of Ontario, Quebec, and the Maritime Provinces, and in the preparation of systematic lists of fossils to accompany field reports. Mr. Lambe takes up the study of the Canadian fossil corals, the results of which will be looked forward to with interest by specialists in this difficult group.

The first field report is that of Mr. J. Burr Tyrrell "On the Doobaunt, Kazan, and Ferguson Rivers, and the North-West Coast of Hudson Bay, to Lake Winnipeg." The region explored (in 1893 and 1894) is embraced in an area of about 200,000 square miles, and lies north of the 59th parallel of latitude, and west of Hudson Bay. The report is accompanied by a coloured map on a scale of 25 miles to 1 inch, and by a number of illustrations, reproduced from photographs, which give a very fair impression of the character of the scenery. Many observations on the natural history of the region are interspersed in these pages which are very interesting reading. Of such is the description given by the author of the immense herds of the barren-ground Caribou (*Rangifer Grœnlandicus*) met with on the shores of Carey Lake, an expansion of the Doobaunt River about 40 miles south-west of Doobaunt Lake. Thousands of these animals were collected together in single herds where the explorers had pitched their tents. "The little fauns were running about everywhere, often coming up to within a yard or two of us, uttering their sharp grunts as they stood and looked up at us, or as they turned and ran back to the does. . . . Later in the afternoon a herd of bucks trotted up to us, and stood at about forty yards distance. This was a most beautiful sight, for their horns are now [30th July] full-grown, though still soft at the tips; but unfortunately we had not the camera with us. We did not shoot any to-day." But this is not the story of the hills, and so perhaps thought our explorer, for he returns in the next paragraph to his geological notes.

The two explorations occupied together 15 months, and included the determination of the geographical features of the vast wilderness travelled over, as well as the character of the rocks and minerals underlying it.

These rocks consist of the following systems:—(1) The Laurentian, which is here "applied almost exclusively to the crystalline, massive or altered, crushed and contorted rocks of the Fundamental Gneiss or 'Basement Complex,' consisting of granites and diorites, and granite- and diorite-gneisses, which it has been impossible to separate in any definite time-series." (2) The Huronian is represented by the Marble Island (Hudson Bay) white quartzite, which Mr. Tyrrell regards as not improbably the oldest part of the Huronian in the region near the north-western shore of Hudson Bay from Marble Island northward to Dawson Inlet southward. This quartzite has associated with it diabase and other basic eruptives, which have been intruded beneath it and have also flowed over it. (3) The Cambrian rocks consist of the Athabasca sandstones and conglomerates occupying the northern part of the region explored. The rock varies from a coarse conglomerate to a fine-grained, red, mottled sandstone, and as no fossils were found in it the age of the formation was determined on stratigraphical and lithological grounds alone. Mr. Tyrrell concludes, however, that as they "hold a position unconformably above the Huronian and below the Cambro-Silurian, they may be assigned with probability to the Cambrian." (4) Two small outliers were the only representatives of the Cambro-Silurian (Ordovician) found within the area surveyed, the one being on an island in Nicholson Lake, the other near Fort Churchill. The fossil contents of these rocks showed them to be of the age of the Trenton Limestone. (5) Silurian rocks were not seen *in situ*, but masses of white limestone scattered along the river-bank near Churchill are referred to that system on the strength of their fossils, one of which, a *Leperditia*, had been submitted to Professor T. Rupert Jones. (6) The Pleistocene period is here indicated by a great glacier (a map of which is given) called by Mr. Tyrrell the Keewatin Glacier, the most northern of three great centres of glaciation—the Cordilleran, the Keewatin, and the Labradorean, constituting a great névé or 'gathering-ground,' from which the ice flowed outward in all directions.

A description of the till, moraines, eskers, ancient beaches, etc., concludes the geological part of this report, to which three appendices are attached, one on Chippewyan names of places, another a vocabulary of words used by the tribe of inland Eskimos inhabiting the banks of Kazan and Ferguson rivers, and the third containing a list of the plants collected.

Mr. Tyrrell's report is followed by a short one by Dr. Bell on the geology of the French River-sheet of the Survey Map, representing the country at the northern end of Georgian Bay (Lake Huron). The object of this report is to condense the information obtained from various reports by the writer and others, the coloured map accompanying it (on a scale of 4 miles to 1 inch) indicating the geological facts, which are therefore sparingly dealt with in the text. If a vertical section could be made from the mainland along the western part of the area surveyed and produced southward through La Cloche Island and the eastern end of Grand Manitoulin Island, it would exhibit the following ascending succession:—

	Feet.
Chocolate marls and fine sandstones (Chazy ?) ...	100
Trenton group	320
Utica formation	60
Hudson River formation	250
Clinton formation	177
Niagara formation	405
Guelph formation (?)	100
	1,412

The Laurentian rocks met with consisted of mica- and hornblende-gneisses in even and regular beds, together with coarse hornblende- and mica-schists and bands of quartz-rock with schistose partings. These dip usually at angles of medium inclination.

The most conspicuous feature of the Huronian system is a whitish quartzite which forms great ridges extending eastward from a point on the mainland north-west of Georgian Bay, and again in a south-westerly direction to Lake Huron. Between these two arms of the quartzite, and northward, the most abundant rock is greywacke, which is associated with varying quantities of quartzites, quartz-conglomerates, agglomerates, breccias, sericite- and mica-schists, impure dolomites, and eruptive greenstones. The whole series, including the quartzites, dips at high angles.

The economic minerals in this region include iron, copper, and nickel, but they are not in sufficient quantity to encourage mining operations.

Mr. A. P. Low's report is based upon a traverse of the northern part of the Labrador Peninsula, from Richmond Gulf (Hudson Bay) to Ungava Bay (Hudson Strait). The route taken lay through Clear Water and Seal Lakes and the Stillwater, Larch, and Koksoak Rivers, the last-named emptying into Ungava Bay. The text is illustrated by remarkably good reproductions from photographs, from which a vivid idea is formed of the essentially barren nature of this northern wilderness.

Some general examination into the geology of the country was obtained as time and opportunity permitted, the object being to supplement the results of the explorations of 1892, 1893, 1894, and 1895 in this region embodied in the Report on the Labrador Peninsula.

Laurentian rocks were met with along the greater part of the route. They consisted chiefly of more or less foliated granite, and of eruptive masses of dark-greenish basic granite and diabase. The contact between the Laurentian granite and the stratified and unaltered rocks of the Cambrian is concealed by the deep clays of the valley of Junction River, where the western wall of the valley is formed of granite, while the east side is composed of cherty dolomite and arenaceous shale. Certain schists and gneisses are also classed as Cambrian, of which they represent a highly metamorphic phase, and to these are added newer intrusions of granite, which have changed the sedimentary Cambrian rocks into schists and gneisses by the heat and pressure due to the intrusion. The unaltered Cambrian rocks, represented by dolomites, shales, and dolomitic sandstones resting unconformably upon Laurentian gneisses, occur on the east coast of Hudson Bay, where at Richmond Gulf they have a breadth of twenty miles. They are traceable also up the Larch River for thirty miles from its junction with the Kaniapiskau. Detailed sections showing the character of the rocks were measured at various places, and these are inserted in the Report, which concludes with a record of the superficial deposits and glaciation of the region traversed.

Dr. L. W. Bailey's report, which is accompanied by a coloured map drawn on a scale of eight miles to one inch, treats of the geology of South-West Nova Scotia, embracing the counties of Queen's, Shelburne, Yarmouth, Digby, and part of Annapolis. This area comprises 3,370 square miles, in which the following groups of rocks are represented:—

1. Granite.
2. Quartzites and slates resembling those of Halifax and Lunenburg Counties, like them auriferous, and believed to be of Cambrian age, but without ascertained fossils.
3. Micaceous, hornblendic, and staurolitic strata, supposed to be the metamorphic equivalents of the Cambrian rocks.
4. Fossiliferous slates and iron-ores of Oriskany or Eo-Devonian age.
5. Red sandstones of Post-Carboniferous age—Triassic?
6. Trap (dolerite, amygdaloid, etc.), associated with No. 5.

The physical features and surface deposits of the region surveyed are next described; its irregular coastline, with long and narrow inlets, whose resemblance to the fiords of Norway was pointed out by Sir Charles Lyell on his first visit to America in 1841; the dunes or sand-hills, moraines, boulders (often of large size), rivers and lakes, kames, and peat bogs; and the glaciation, very strongly marked in the rocks upon the coast, forming in some places deep, trough-like hollows.

The underlying rocks, largely consisting of those provisionally referred to the Cambrian, exhibit evidence of profound metamorphism in some parts of the area, while in others they are but little altered; these two conditions passing into each other by insensible gradations. They are separated by Dr. Bailey into three divisions: I, the Quartzite Division; II, the Banded Argillite Division, consisting of grey and purple slates; and III, the Black Slate Division. These rocks have been affected by the earth movements which have influenced the rock formations along the whole eastern coast of America, and present a series of domes or ridges, usually anticlinal in structure, around which are enwrapped the remains of the higher and less resisting slaty beds. The total area covered by the Cambrian rocks in the district examined is computed at 1,000 square miles.

Siluro-Devonian beds occur in small patches in Annapolis and Digby Counties. It is concluded from the fossils derived from these deposits, determined or re-examined by Dr. H. M. Ami, "that the beds hold forms referable, some to a transitional series, and other to a horizon at the base of the Devonian [Eo-Devonian of H. S. Williams]," and this is "in accordance with the stratigraphy of the district, which indicates a perfectly continuous and conformable series of beds."

Red sediments, assigned with a query to the Triassic epoch, underlie the Annapolis Valley, and traps occurring in the long bu interrupted ridge forming the North Mountain of Annapolis County Digby Neck, Long and Briar Islands, are regarded as possibly o contemporaneous origin.

Among the economic minerals of this part of Nova Scotia gol occupies an important place. The results of mining the precio metal, though apparently somewhat checkered, seem to have bee on the whole of an encouraging nature, and there are some properties yielding good returns and promising still better. A detaile account of the gold-mining industry is given by Dr. Bailey in h report, and he also refers to the ores of iron found and worked the area under review. Excellent 'process' illustrations enrich th report similar to those of the other reports in this volume.

Dr. G. Christian Hoffmann's report of the section of Chemistry a Mineralogy contains a record of the more interesting results obtain by the examination and analysis of various rocks and minerals submitted to him, in which his assistants, Messrs. Waite and Johnston, bore their share.

In the section of Mineral Statistics and Mines (Annual Report for 1896) Mr. E. D. Ingall, assisted by Messrs. Cole and McLeish, makes an important contribution to this subject, so vital to the interests of a country possessing the mineral wealth of Canada. A few words from the introduction to this report will suffice to show what rapid strides the country is making in mineral development. "In 1886 the total mineral production of the country, as per direct returns, supplemented by close estimates where complete returns could not be obtained, was valued at a little over ten million dollars. In 1896 the value of Canada's mineral production had increased 125 per cent. or to over twenty-two and a half million dollars."

The Report closes, as usual, with a good Index.

ARTHUR H. FOORD.

REPORTS AND PROCEEDINGS.

February 17, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

ANNUAL GENERAL MEETING.

The Secretary read the Reports of the Council and of the Library and Museum Committee for the year 1898. In the former the Council congratulated the Fellows on their increase in numbers and on the continued financial prosperity of the Society.

During 1898 the number of Fellows elected was 52: of these qualified before the end of the year, making with 17 previously ected Fellows, a total accession of 58 in the course of the relvemonth. During the same period, the losses by death, resig- ition, and removal amounted to 52, the actual increase in the imber of Fellows being 6.

The total number of Fellows, Foreign Members, and Foreign orrespondents, which on December 31st, 1897, was 1,333, stood t 1,339 by the end of 1898.

The balance-sheet for the year 1898 showed receipts to the mount of £3,575 7*s.* 1*d.* (including a balance of £723 3*s.* 0*d.* rought forward from the previous year), and an expenditure of 2,499 6*s.* 5*d.*, the balance remaining available for the current ear being £1,076 0*s.* 8*d.*

The Secretary of H.M. Office of Works having announced that he Department proposed to lay down a new system of drainage in onnection with the Society's apartments, the Council had pointed ut the need for improved lavatory accommodation. This the Office f Works consented to provide, on condition that the Society shall ontribute the sum of £200 towards the cost thereof—a proposal hich the Council advised the Fellows to accept.

It was announced that the MS. of the Third Volume of Hutton's Theory of the Earth," edited by Sir Archibald Geikie, is now in e press, and that it is proposed to print a number not exceeding 00 copies.

The completion of vol. liv and the commencement of vol. lv f the Society's Quarterly Journal was mentioned, and attention as called to the fact that in this and future years the Record of eological Literature added to the Society's Library will be issued oncurrently with the May number of the Journal. Reference was lso made to the issue of Index Slips with each number.

The new system adopted during the past year with regard to the election of papers for publication in the Quarterly Journal was xplained, and the awards of the various medals and proceeds of onation funds in the gift of the Council were announced.

The report of the Library and Museum Committee enumerated e large additions made to the Society's Library during the past ear, and announced the approaching completion by Mr. C. Davies herborn of the work of labelling and registering the type- and ther interesting specimens in the Museum.

The reports having been adopted, the President presented the Vollaston Medal to Professor Charles Lapworth, LL.D., F.R.S., ddressing him as follows:—Professor Lapworth,—

On four occasions has the Council of this Society already delighted to do you nour, with the Murchison Fund in 1878, with the Lyell Fund in 1882 and 1884, d with the Bigsby Medal in 1887. Our Funds are usually awarded with the sire of helping observers and of stimulating them to further efforts, and from this int of view the Funds awarded to you have certainly been most profitable investents. Nor could the Bigsby Medal, with its age-limit, have been better bestowed an on one who had done so much and such good work before reaching the age 45.

At that time, however, the effect of your work could hardly be appreciated to the full. I believe that the appreciation of it will increase as time goes on, and I am glad to know that in an elaborate Memoir on the Silurian Rocks of Scotland, shortly to be published, the Officers of the Geological Survey do full justice to your series of papers on those rocks in the South of Scotland, saying that you have furnished a complete solution of the stratigraphical and palæontological difficulties of the subject, and have discovered the key to the complicated stratigraphy of the region. The summary, at the end of the chapter on Previous Researches, is written "to place clearly on record the distinctive features of Professor Lapworth's achievements, ... which resulted in establishing the true order of succession of the strata."

We hardly know, indeed, which to admire most, the brilliance of your work or the single-mindedness with which it has been done; not only in the Scottish Uplands, but also in the still more remarkable region of the North-Western Highlands, where the officers of the Geological Survey have now worked out in detail that most complicated structure which you so justly appreciated.

In establishing the Ordovician System, too, you have done your best to promote harmony between the rival claimants for Cambrian and for Silurian.

Since the Bigsby Medal was awarded to you your labours in various branches of Geology have been continued, notably in further working out the structure of the Southern Uplands of Scotland, in the discovery of the English *Olenellus*-rocks, and in additions to our knowledge of the *Olenellus*-fauna and its geological relations. Your researches on the ancient rocks of Shropshire have been published only in abstract; the striking results at which you have arrived lead us to hope that ere long they may be published in full.

In your address to the Geological Section of the British Association in 1892, you astounded your hearers by the way in which you applied your knowledge of mountain-structure to questions of the largest kind, showing a breadth of view that had not been surpassed by any geologist.

Lately, and in quite another line of work, in that admirable Sketch of the Geology of the Birmingham District, issued by the Geologists' Association last year, you have given us one of the best accounts of any English district that we possess, weaving in the work of others and giving it the character of a perfect fabric.

It is not only, however, for your work as a geologist that we wish to honour you, but also for your work as a teacher. In saying this, I do not refer merely to your professional work, excellent though it be, but rather to that highest of all teaching, the influence that you have had on your fellow-workers in Geology. That influence is to be traced in much of the best work that we have had of late years, and during our present Session we have had important papers which, I venture to say, would not have been written but for lines of thought suggested by you. We look forward to a long continuance of your brilliant labours.

Professor Lapworth replied in the following words:—Mr. President,—

I am deeply grateful to the Council of the Geological Society for the great honour which they have conferred upon me by the award of the Wollaston Medal; and to you, Sir, for the kindly, and indeed too kindly, terms in which you have referred to my scientific work.

It was my happy lot to have, at the very outset of my geological career, the aid and encouragement of a master in the science—my dear friend, the late Professor Alleyne Nicholson. It has been my good fortune to live in districts where some new geological work could be done. And more, since the day when I read my first geological paper, I have been encouraged and stimulated by the friendship and the sympathy of many earnest geologists.

When I think of my many opportunities, and remember how often my results have fallen sadly short of my aims, I feel that this distinction is less a reward than a consolation. But I accept it as an outward and visible sign that the Council are well aware that the same instinctive love for our glorious and all-embracing science as that which inspired those whose names adorn the illustrious roll of the past Wollaston Medallists, has also prompted and guided me in my work, and has given me a place in the generous regard of the Fellows of the Geological Society.

In handing the balance of the proceeds of the Wollaston Donation Fund (awarded to Prof. J. B. Harrison, M.A., F.G.S.) to Mr. J. J. H.

eall, M.A., F.R.S., for transmission to the recipient, the President dressed him as follows:—Mr. Teall,—

I have the pleasure of handing over to you the balance of the Wollaston Fund for ofessor J. B. Harrison, in acknowledgment of his work in the West Indies and itish Guiana. In the course of the last eight years he has contributed several pers to the Society (in conjunction with Mr. Jukes-Browne and Mr. G. F. Franks) the Geology of Barbados, which have added much to our knowledge of old coral-efs, of the past physical geography of the region in which they occur, and of the eanic deposits with which they are associated. In this work, his ability as chemist has been of great service.

He has also done most of the field-work for the Geological Map of Barbados, and s visited other West Indian Islands and part of British Guiana, in order to draw official reports on soils and gold-bearing rocks. In the last of these visits, made st year, he suffered repeated and nearly fatal attacks of fever, from which he was wly recovering in December, when we last heard from him.

Mr. Teall replied in the following words:—Mr. President,—

In handing this award to me for transmission to Professor Harrison, you place me a somewhat unusual position. No communication has been received from Professor arrison since the award was decided upon by the Council. All that we know bout him is that, in December last, he was recovering from an illness brought on by ork in the interior of British Guiana, and was contemplating a journey to Barbados n January. The fact of our not having received any acknowledgment from him is, therefore, probably due to his absence from Georgetown.

I need not repeat what you, Sir, have said about his scientific work in the West Indies and British Guiana. He is a man who, in the midst of professional engagements, and without the stimulus of frequent, sympathetic intercourse with fellow-workers in science, has yet found time to carry out important scientific researches in far-distant British Colonies. I feel sure that he would wish me to express, on his behalf, the deep sense of the honour which has been conferred upon him, and to assure the Society that this mark of their appreciation will encourage him to continue his scientific work.

The President then presented the Murchison Medal to Mr. B. N. Peach, F.R.S., and a second Murchison Medal to Mr. J. Horne, F.R.S.E., addressing them as follows:—Mr. Peach and Mr. Horne,—

Since the years 1887 and 1888, in which the Wollaston Fund was awarded to you uccessively, you have continued your work in Scottish Geology, taking a leading part n the latter year in that Report on the Recent Work of the Geological Survey in the orth-Western Highlands, printed in our Journal, in which the new view of he structure of that region is described in some detail. You have also dealt with he *Olenellus*-zone in the same district, and, ascending greatly in the geological scale, ou have discussed Glacial geology and have undertaken Cavern-research.

Mr. Peach, moreover, has done much palæontological work, having long acted s Palæontologist to the Scottish Survey, and it should not be forgotten that he escribed the first fossil scorpion found in the Silurian rocks of Scotland. He has lso given us a paper on some additions to the fauna of the *Olenellus*-zone, and has oticed a radiolarian chert of Arenig age.

Mr. Horne, either alone or in conjunction with other colleagues, has given us paper on "Foliated Granites and their Relations to the Crystalline Schists," owing an intimate relation between the two rocks and that the foliation in the rmer may have originated in at least two ways; he has communicated other papers the Geological Society of Edinburgh, on igneous rocks, on volcanic necks, on ssiliferous Cambrian and Carboniferous rocks, and on glaciation, taking part also the Report of the British Association Committee on the Shelly Clays of Clava and intyre, and in the work of the Inverness Society.

Your association together has been productive of much good work, and we hope hat it may long continue. In handing the Proceeds of the Wollaston Fund to one f you in 1888, Professor Judd remarked that as in your researches you had been so onstantly united, in the recognition of your services you should not be divided, and hat the name of Horne would appropriately follow that of Peach. On the present occasion, I am glad to say that we have allowed no interval between the names, but have, still more appropriately, I think, than before, coupled them together by awarding a Medal to each of you. This award seems to me to go very naturally with that of the Wollaston Medal to Professor Lapworth, as you have both so largely helped in the detailed working-out of subjects that he brought before you.

Mr. Peach, in reply, said :—Mr. President,—

The honour which the Council of the Geological Society have conferred upon me is highly prized by me, because it was by the advice of Sir Roderick Murchison that my thoughts were turned to Geology as a career in life. By means of his generosity I was able to avail myself of the scientific training afforded by the Royal School of Mines, and through his nomination I received an appointment on the Geological Survey.

I ask you, Mr. President, to convey my heartfelt thanks to the Council for having awarded me the Murchison Medal which, for me, has such tender associations. If anything could enhance the pleasure of this Award, it is the receiving it from the hands of one colleague and the sharing of it with another.

Mr. Horne also replied, as follows :—Mr. President,—

It is a source of great gratification to me that I have been deemed worthy by the Council of this Society to receive the Murchison Medal jointly with my old friend and colleague, Mr. Peach. For he gave me my early training in field-work, and to his range of knowledge and ample experience I have owed much during my Survey career.

It is likewise a special pleasure to be linked with the great founder of this Medal, whose name is so closely associated with the history of Scottish Geology. While preserving a feeling of loyalty to our former chief and his successors in office, we have at the same time tried to exercise independence of judgment in dealing with Scottish geological questions. In doing so, we have realized, perhaps more vividly than others, the permanent value and brilliant power of Professor Lapworth's researches in Scotland, whose reception at this anniversary of the highest honour which the Council can bestow is a great pleasure to us. Regarding the Geology of the North-Western Highlands, we feel that our colleagues who have worked with us in that complicated region justly share in the honour which has been conferred have conferred upon him. His long life has been enthusiastically devoted to geological pursuits. Before he joined the Geological Survey, the scanty intervals of leisure which he could snatch from the daily toil of his avocation were given up to the search for fossils among the Carboniferous and Pleistocene deposits around Glasgow. When he became Fossil-Collector to the Survey he was enabled to pursue as his regular and ordinary employment what had before been the occupation of his brief hours of recreation. And now, having passed the age-limit of the Civil Service, and having retired on a small pension, he continues to work on in his old way, and appears daily still in his accustomed place in the Survey Office, busy with the search for micro-organisms among the silt and peat which he gathers from some of the floors of vanished Arctic lakes around Edinburgh. The stores of knowledge which he has slowly amassed have always been at the disposal of others who could make good use of them. That his quiet, unobtrusive labours should have attracted the notice and received the approbation of the Geological Society has been to him a source of deep gratification. As long as life and strength remain, he will continue the work which has been the chief pleasure and solace of his career.

The President then presented the Lyell Medal to Lieut.-Gen. C. A. McMahon, F.R.S., addressing him as follows:—General McMahon,—

Besides your petrological work in India you succeeded, by work in the field as well as with the microscope, in tracing out the relations of the gneissose granite or central gneiss of the Western Himalayas, and in proving its intrusive character as well as its Tertiary age. You thereby threw much light on the theory of the origin of that great range, to a knowledge of the Glacial geology of which you have also contributed.

Returning to this country, you have given our Society several papers, chiefly on the rocks of Cornwall and of Devon. In these you have contended that the serpentine of the Lizard district is intrusive, that the banded structure of the accompanying gabbros is due to fluxional movements, and that the granite of Dartmoor is an intrusive igneous rock of the usual character. These papers and various communications to the GEOLOGICAL MAGAZINE show that, besides being a skilled observer, you have the valuable adjunct of critical ability, combined, I need hardly say, with all courtesy. Kindred Societies, too, have had the benefit of your work, in the microchemical examination of minerals among other things. Nor has your Indian experience remained unused.

Labouring under the disadvantage of taking to the study of Geology comparatively late in life, you have attacked it with the energy of a British soldier, and have fought your way into the foremost ranks of our petrologists.

Lieut.-Gen. McMahon, in reply, said:—Mr. President,—

I feel deeply the honour conferred upon me by the Council of the Geological Society in awarding to me the Lyell Medal, as a recognition of my humble efforts to advance the cause of Geological Science. The pleasure which this has given me is greatly enhanced by the kind and flattering way in which you have spoken of my work, and by the sympathy accorded to me on this occasion by the Fellows of the Society.

It is very gratifying for an amateur to have his work stamped with the hall-mark by specialists who have made Geology the study of their lives. I have always received help and encouragement from professional geologists, and had it not been for the generous aid which they have invariably been ready to afford, I should not this day have been a recipient of the Lyell Medal.

In handing to Mr. Frederick Chapman, A.L.S., F.R.M.S., a moiety of the balance of the proceeds of the Lyell Geological Fund, the President addressed him in the following words:—Mr. Chapman,—

You have been an enthusiastic worker with the microscope for many years, and half of the balance of the Lyell Fund has been awarded to you as a mark of our regard for what you have done for the fossil Foraminifera and other Microzoa, much of your work being published by the Royal Microscopical Society.

Your earlier papers, written in conjunction with Mr. Sherborn, were based on the London Clay of our immediate neighbourhood, and then on that of Sheppey.

You have also dealt with the Foraminifera of the Gault, writing a set of te papers specially on the Gault of Folkestone (1891–98). The microscopic faun of the Phosphatic Chalk, of the marl and silts of Barry Docks, and of Barbado deposits have been described by you in our Journal, and you have also given us a elaborate paper on the Bargate Beds and their Microscopic Contents (1894). Rhæti Foraminifera you have described in the Annals and Magazine of Natural History Pleistocene Ostracoda and Jurassic Microzoa in the Proceedings of the Geologist Association, nor have you neglected recent Foraminifera.

That you should have so well used the opportunities which you have had whi serving under Professor Judd is a source of satisfaction to us, and we hope that th award may be an encouragement to you in further researches.

Mr. Chapman, in reply, said:—Mr. President,—

I desire to express my sincere thanks to the Council of this Society for selecting m as one of the recipients of the Lyell Award, and to you, Sir, for the very encouragi words with which you have honoured me. However little my work in the past m have merited this distinction, I trust that, with further opportunities, my la endeavours in Micropalæontology and other branches of microscopical work will some degree justify this selection. I cannot let this occasion pass, without sayi how much direct help and advantage I have derived from the methods of geologi research carried out in Professor Judd's laboratory at the Royal College of Scien Nor would I forget the invaluable advantages which I have derived from the frie ship of those engaged in the same line of research, and especially are my obligati due to Professor T. Rupert Jones and Mr. C. Davies Sherborn.

The President then handed the other moiety of the balance the proceeds of the Lyell Geological Fund to Mr. John Ward F.G.S., addressing him as follows:—Mr. Ward,—

One-half of the Balance of the Lyell Fund has been awarded to you, in recognition of your long services to the Geology of your district. You have devoted many years to the study of the Geology of North Staffordshire, making a large collection of fossils, especially Vertebrata, from the Coal-measures, including many new forms, and thus aiding, with material, the researches of various palæontologists, including Egerton, Huxley, and Traquair.

For nearly 40 years you have contributed valuable papers to local societies and to mining institutes, among which is a detailed essay on the Geological Features of the North Staffordshire Coalfield and the record of a rich marine fauna in certain horizons of Coal-measures. Your detailed and accurate knowledge of the district has always been freely placed at the service of other observers.

Mr. Ward, in reply, said:—Mr. President,—

It is difficult for me adequately to express my appreciation of the high honour conferred by the Council of the Geological Society in awarding to me a moiety of the balance of the Lyell Fund; and to yourself, Sir, my best thanks are due for the complimentary terms with which you have supplemented it.

Forty years and upwards have now passed away since I was first led by the inspiring influence of an old and much revered friend, the late Dr. Garner, author of the "Natural History of the County of Stafford," to devote my leisure hours to the investigation of the fossil fauna and flora of the North Staffordshire Coalfield.

It has been my good fortune to labour in a field which, although local, is one that affords abundant facilities for research in Carboniferous Palæontology, and to have been led to the investigation of a branch of our science which had previously been greatly neglected. My attention has principally been directed to one special line of research—the fossil Vertebrata, of which class I have collected between 3,000 and 4,000 specimens of fossil fishes and reptilian remains. Of the former, about 40 genera and species are new to science, in addition to many rare and unique examples. Within the past few years, the principal portion of my collection has been added to the National Collections in Cromwell Road, whilst another portion enriches the geological collection in the Edinburgh Museum.

I avail myself of the present opportunity to acknowledge my gratitude to the many eminent palæontologists to whose generous assistance and encouragement I owe so much of my success. To Dr. Traquair my thanks are specially due for the valuable assistance and friendly aid accorded to me during the past eighteen to twenty years. Not only has he assisted in naming specimens, but he has contributed to science a number of papers and separate monographs devoted to the elucidation of the structure and affinities of new and rare genera and species of fossil fishes from my collection.

I shall look upon the award not only as bearing the stamp of approval and generous recognition of the Council of the Society for my past services to Palæontological Science, but also as an additional incentive to me to continue with renewed energy those researches the pursuit of which has been to me a labour of love for so many years. It will be not only my aim, but my highest ambition, in the time that yet remains to me, to contribute to our common science results that will be of greater scientific value than anything I have hitherto been able to offer, and to render myself more worthy of the distinction which has been conferred upon me.

The President in handing the Bigsby Medal (awarded to Professor T. W. Edgeworth David, B.A., F.G.S.) to Professor J. W. Judd, C.B., LL.D., F.R.S., for transmission to the recipient, addressed him in the following words:—Professor Judd,—

As, after studying under Sir Joseph Prestwich at Oxford, Professor David had the advantage of attending your courses at the Royal College of Science, it is fitting that you should receive the Bigsby Medal for him.

After having engaged in an investigation of the Glacial phenomena of his native district, South Wales, the results of which were published in our Journal and reprinted by the Cardiff Naturalists' Society, Professor David was appointed to the Geological Survey of New South Wales, and during his nine years' service thereon many reports and maps, as well as independent papers on various branches of our science, show his devotion to his work.

In 1891, having been made Professor of Geology in the University of Sydney, he threw himself with energy into the work of teaching.

Among the series of scientific communications from his pen, two must be specially remembered by many of us, namely, his paper on Evidences of Glacial Action in Australia in Permo-Carboniferous Time, ably delivered by himself in this room in 1896, and generally thought to be the most convincing on the subject, and lately the equally important paper on the Radiolarian Cherts of New South Wales, read, in his absence, by Dr. G. J. Hinde.

Besides so much good work in his own Colony, he has greatly assisted in the investigation of the Coral-atoll at Funafuti, and it is to his energy and perseverance that the success of this undertaking is largely due.

The Council of the Geological Society do not forget our Colonial brethren, but delight to honour those who, like Professor David, do good work in our far-off lands.

Professor Judd, in reply, said:—Mr. President,—

On behalf of my friend, Professor Edgeworth David, I thank you for the kindly terms in which you have spoken of his work. Part of that work is known to all Fellows of this Society, by the papers which Professor David has contributed to our Journal. But another, and very large part, is the record of geological studies carried on during the last twenty years in his adopted country—the great Colony of New South Wales. There is, however, one labour of his, which I believe will prove to be of especial importance in advancing Geological Science. I refer to what he has done in connection with the boring of a Coral-atoll in the Pacific Ocean. Three expeditions in successive years have resulted in the carrying down of the boring at Funafuti to the depth of 1,114 feet. The leader of the first expedition—Professor Sollas—assures me that he owed much to the aid and good-will of Professor David in starting this important enterprise. In the second expedition, Professor David, with his accomplished and energetic wife, went out to Funafuti, and they were largely instrumental in overcoming the serious difficulties of the work. The third expedition, in which the triumph of the investigation was finally assured, would probably never have been set on foot but for his indomitable perseverance, and for the tact and the influence which Professor David brought to bear on all who could aid in this important undertaking. The last portion of the core obtained by the Funafuti boring will probably be in this country within a few days, and, from what I have seen of the other parts of the core, I am convinced that its study by zoologists, botanists, and chemists will result in new information being obtained concerning the origin of coral-reefs—information which will prove of inestimable value to the geologist.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last Annual Meeting, including W. Dames (elected F.M. in 1895), C. W. von Gümbel (F.M. in 1877), James Hall (F.M. in 1848), J. Marcou (F.M. in 1879), Fr. von Sandberger (F.M. in 1875), A. Briart (F.C. in 1884), W. G. Atherstone (elected a Fellow in 1864), M. Attwood (elected in 1876), D. Bell (elected in 1892), W. Colchester (elected in 1857), Sir J. Fowler (elected in 1845), W. C. Lucy (elected in 1861), H. A. Nicholson (elected in 1867), T. Sopwith (elected in 1872), E. Wilson (elected in 1872), and others.

He then drew attention to various subjects in which Geology has a practical application. Firstly, as regards water-supply, the geology of the gathering-ground is always of importance. In selecting sites for reservoir-dams certain sorts of ground have generally to be avoided, as of unstable character, whether from great disturbances, from the occurrence of irregular masses of Drift, or from landslips. The presence of pervious beds in a reservoir may also lead to trouble. Illustrations of these matters are given by some of the waterworks for Manchester and for Sheffield.

In getting water by means of wells, geological considerations are of great importance in fixing sites. While we can see springs and streams, we have to infer much in dealing with underground water. For large supplies we must go to permeable formations of fair thickness and of broad outcrop, and should select sites where a large area of gathering-ground can be brought under contribution. The flow of water underground has to be studied, and the character of the water-bearing rocks noticed, although there is often much difference in this latter between beds at or near the surface and the same beds at great depths underground.

Waters, too, vary with their depth, those found near the surface often differing greatly in mineral contents from those in the same beds at great depths: as, for instance, the waters of the deep wells in London compared with those of wells in the bare chalk.

In selecting sites for sewage-farms and for cemeteries, Geology is again of importance, and it is especially needful to prevent the contamination of water-bearing formations. A recent research of Dr. Klein is of great interest, as showing the strong filtering-power of fine compact sand in stopping the passage of microbes, whether in water or in the dead bodies of guinea-pigs.

Illustrations of the evil results of neglect in the protection of water-supplies from contamination are given by the outbreak of fevers at Worthing, with a well-supply, and at Maidstone, with a spring-supply.

For the proper consideration of all these questions, it is needful to have, firstly, a map on which the divisions of the Drift are shown; and, secondly, a geological map on a large scale. Reference was made work of the Geological Survey in these and in other practical ions.

Ballot for the Council and Officers was taken, and the following were declared lected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; or T. G. Bonney, D.Sc., LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., , F.R.S.; E. J. Garwood, Esq., M.A.; J. W. Gregory, D.Sc.; Alfred r, Esq., M.A.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Henry M.D., F.R.S.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D., F.R.S.; . Hudleston, Esq., M.A., F.R.S., F.L.S.; Professor J. W. Judd, C.B., , F.R.S.; H. W. Monckton, Esq., F.L.S.; F. W. Rudler, Esq.; Professor . Seeley, F.R.S., F.L.S.; A. C. Seward, Esq., M.A., F.R.S.; Professor Sollas, M.A., D.Sc., LL.D., F.R.S.; A. Strahan, Esq., M.A.; Professor . Watts, M.A.; W. Whitaker, Esq., B.A., F.R.S.; Rev. H. H. Winwood, ; A. S. Woodward, Esq., F.L.S.

icers.—*President*: W. Whitaker, Esq., B.A., F.R.S. *Vice-Presidents*: Hicks, M.D., F.R.S.; Professor J. W. Judd, C.B., LL.D., F.R.S.; sor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; Rev. H. H. Winwood, M.A. *ries*: R. S. Herries, Esq., M.A.; Professor W. W. Watts, M.A. *Foreign ry*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer*: Blanford, LL.D., F.R.S.

CORRESPONDENCE.

EGYPTIAN CRETACEOUS SHELLS.

,—Dr. Blanckenhorn, of the Geological Survey of Egypt, has tly favoured me with some detailed evidence, which goes to that a part of the Cretaceous mollusca from Egypt described in the Geological Magazine for 1898, p. 394, as having been ted in districts eastwards of the Nile and Nile Valley, are of anian age, and not Turonian. This renders it desirable to d the following species as Campanian: *Ostrea Lyonsi*, *O. Villei*, *cardia biseriata*, *Trigonoarca multidentata*, and *Arctica Barroisi*. lanckenhorn further calls attention to the Cretaceous rocks of Roasch, which he recognizes as belonging to the two horizons ronian and Santonian, and not to the former only, as indicated paper. In support of this age I alluded to the discoveries of ules Welsch among similar deposits in Algeria; and without ting this information I feel justified, in the absence of more rtant palæontological evidence from this area of Egypt, in lering these beds as Turonian. R. Bullen Newton.

SUB-OCEANIC PHYSICAL FEATURES.

,—I must reply to Professor Hull's very kind letter that I *do* that it may have been in consequence of their original union o sides of a rent, that the physical features on the opposite of the Atlantic possess a remarkable similarity. I wish to e of those who are studying the submarine declivities, whether t this similarity is more marked in them than in the coastlines. was expressly for the purpose of eliciting opinions upon this ion that I wrote. Professor Hull gives his, that such a rent ossible. I should imagine that he has not fully considered my

"Speculation on the Origin of Ocean Basins," or he would have given his reasons for saying so. The matter appears to me to turn upon the question, whether there was a hardened crust upon the earth at the time of the genesis of the moon, or whether there was not. If there was, I do not see any impossibility in my explanation of the origin of the oceans; and it agrees with several remarkable facts, such as the greater density of the crust beneath the oceans, and this very point of the apparent rent between the Eastern and Western Hemispheres. It is obvious that, if my speculation is correct, we need go no further to account for the origination of these great declivities.

I would respectfully ask geologists interested in this subject to refer to my article in *Nature*, vol. xxv (1882), p. 243, or to chap. xxv of my "Physics of the Earth's Crust," second edition, that they may see what my speculation really is before rejecting it.

O. FISHER.

HARLTON, CAMBRIDGE.
March 7, 1899.

THE EASTERN SLOPE OF THE NORTH ATLANTIC BASIN: IS IT A STEEP OR A GRADUAL INCLINE?

[The Editor has received the following note from Rear-Admiral Sir William Wharton, K.C.B., F.R.S., the Hydrographer of the Admiralty; and as it bears directly upon the nature of the so-called 'escarpment' of Professor Hull, referred to by Mr. A. J. Jukes-Browne in his recent letters, and also to Mr. Hudleston's important

On examining the soundings the slope will be found to vary 6 feet to 19 feet dip in 100 feet horizontal, a dip that cannot ibly injure or strain the cable.”

ith regard to the remaining portion of the slope to the south-d into the Bay of Biscay, it has never been examined with a view scertaining the angle. Though in time a great many soundings e been accumulated, as the charts will show, they are the results nany ships, and you will understand that, as a consequence of the ertainty of finding the precise position of a ship at sea, when the lts of two or more ships are compared, there may be considerable rs. But from what we have, the result is the same, i.e. a gentle e varying from 2° to 10° from the horizontal.

send you some slopes drawn from what information we possess, ich include the edge of the deep water from 46° N. lat. to 54° N. lat., which speak for themselves. You will see that the angles are say. I may further mention that I know of no steep submarine cipices in the oceans in any part of the world, except those round al islands, and perhaps in a few cases round the edges of merged banks, doubtless of volcanic origin.

W. J. L. Wharton.

OBITUARY.

WILHELM BARNIM DAMES.

Born June 9, 1843. Died December 22, 1898.

y the death of Professor Dames, Germany loses one of its most palæontologists, and the University of Berlin one of its st distinguished Professors. Born at Stolp, in Pomerania, in 1843, studied at Breslau under Ferdinand Roemer, and also at Berlin ler Beyrich. He graduated at Breslau in 1868, his thesis on Devonian rocks of Freiburg, Lower Silesia, being published the German Geological Society in the same year. The troublous es of the Franco-German War then interrupted his researches, in September, 1870, he was wounded near Chevilly. After very he went to Berlin, in 1871, as assistant in the Geological seum of the University, and became Custos in 1875. He was ointed Professor Extraordinarius in the University in 1878, and promoted to an ordinary professorship, on the death of Beyrich, 1891. He was elected a member of the Prussian Academy Sciences in 1892.

uring the first decade of his scientific researches Professor nes was occupied chiefly with fossil Invertebrata, and his most ortant contribution was his description of the Echinoidea of Jurassic of N.W. Germany, published by the German Geo-cal Society in 1872. In 1881 he began to take special interest he Vertebrata, publishing a small note on some Selachian teeth *ombodus Binckhorsti*) from the Maastricht Chalk. At this time was entrusted with a memoir on the famous second specimen *Archæopteryx*, which was published, in 1884, in vol. ii of the læontologische Abhandlungen”—a valuable serial founded by

Professors Dames and Kayser, on the plan of the older " graphica," in 1883. The memoir on *Archæopteryx*, wit supplement in 1897 (Sitzb. k. preuss. Akad. Wiss.), w one of the classics of Palæontology. After a visit Professor Dames described some remains of *Hyænarct* and a rodent from Pikermi (1883) ; while in 1888 h temporarily to the study of Invertebrata, publishing a Crustacea from the Cretaceous of Mount Lebanon. important memoirs of his later years were those on t Fishes of the Muschelkalk (1889), on Chelonia from German Tertiaries (1894), on Zeuglodont remains fr (1894), and on *Plesiosaurus* from the Lias of Southerr (1895). Of these, the first three were published in the ' logische Abhandlungen," while the fourth was a mem Prussian Academy. At the time of his death the Pr in preparation a description of the Neocomian fishes of I Hanover, and a paper on *Stereosternum* from Brazil.] onwards he had been joint-editor of the "Neues Jal Mineralogie."

Professor Dames travelled extensively in Europe anc known in this country, where he was honoured by Foreign Correspondent to the Geological Society of 1891, and as Foreign Member of the same Society in married a Russian lady, Baroness Mathilde von Toll, c in Esthonia. His last journey was one in the vain searcl through Norway, during the summer vacation of 1898.

O. C. Marsh

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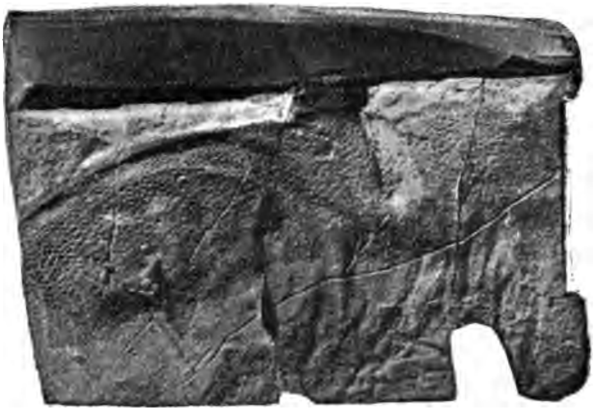
ORIGINAL ARTICLES.

I.—NOTE ON A NEW AUSTRALIAN *PTERYGOTUS*.

By Professor Sir FREDERICK McCOY, K.C.M.G., M.A., D.Sc. (Cantab), F.R.S.

I AM greatly indebted to Mr. F. Spry for bringing to my knowledge some extremely interesting Upper Silurian fossils collected by him with great care and diligence from the tunnels excavated through the rocks underlying Melbourne during the progress of the new great drainage works for the city, carried out by the Metropolitan Board of Works. The age of the strata containing these fossils was originally determined by me for Selwyn's Geological Survey Maps of Victoria.

Four of these fossils belong to genera hitherto unknown in the Victorian rocks, and belong to groups of special interest. I subjoin preliminary descriptions of one of these, that credit may be secured to Mr. Spry for his scientific zeal in doing such good service to geology while carrying out his professional duties.



Pterygotus Australis (McCoy). Upper Silurian: Melbourne.

This is represented by about half of a somatic segment of a species most nearly resembling the *Pterygotus bilobus* (Salter) of the black laggy uppermost Silurian rock of Lesmahago, which the matrix of his specimen, from the main sewer tunnel in Domain Road, South Yarra, almost exactly resembles. The anterior margin is slightly convex to the front (as usual), slightly thickened, and the anterior covered border smooth and concave (preserved for about three lines in antero-posterior length). The dorsal surface, from the anterior margin to about ten lines back, is covered with the characteristic scale-like markings of the genus, composed as usual of semi-oval, narrow, prominent ridges, the wide open part of the curve directed forwards and the convexity backwards, averaging about ten in longitudinal and about seven in transverse direction in six lines, and rather more regularly equal than in *P. bilobus*. The entire antero-posterior length of the segment is 2 inches 5 lines, the posterior portion, of about 1 inch 9 lines, as usual in the genus, being free of scale-like sculpturing. The entire breadth of segment I estimate would have been about 6½ inches.

None of the Merostomatous Crustacea have been found before in this country, and Mr. Spry has presented the type-specimen to the National Museum.

II.—On the Occurrence of Allanite in the Hornblende-Granite of Lairg, Sutherlandshire.

By Lieut.-General C. A. McMahon, F.R.S.

In the September number of the Geological Magazine for 1898, Mr. J. S. Flett, B.Sc., describes, at p. 388, the occurrence of Allanite in the granite of Fell Hill, Cree Town, Kirkcudbrightshire, and in a biotite gneiss in Sunday, one of the Orkney Islands.

I have recently been re-examining a slice taken from a sample of a good pocket lens. The mineral possesses considerable lustre, and bright facets catch the light and facilitate its isolation. Crystalline faces are numerous and often suggest those shown at fig. 4, p. 522 of Dana's "System of Mineralogy," 6th edition. The fracture of the mineral is subconchoidal.

The specific gravity of the Lairg mineral is over 3·32, and consequently it sinks readily in methylene iodide. It would be difficult to ascertain the exact specific gravity of the Lairg mineral, as, owing to the microscopic size of the fragments, heavy liquids of viscous character—as, for instance, cadmium borotungstate above a certain density—are of no use.

The refraction of the mineral is also high, being well over 1·740 that of methylene iodide. On the other hand its double refraction is weak, exhibiting no colour higher than a decidedly dull yellow of the 1st order of Newton's scale.

The pleochroism of the Lairg mineral is usually distinct and occasionally strong, the change of colour being from a brown-red, or red-brown, to a brown-yellow. Sometimes, but rarely, there is a suspicion of green in the brown.

As regards the optical character of the crystals the Lairg specimens are positive. I have been able to observe the interference figure in convergent polarized light in many of the isolated fragments, and its sign is uniformly positive. Dana, in his "System of Mineralogy," 6th edition, 1892, says that allanite is optically negative; but Michel Lévy, in his "Les Minéraux des Roches," gives the sign as ±. The Lairg specimens therefore support Michel Lévy's view.

Mr. J. J. Harris Teall, F.R.S., has very kindly allowed me to examine thin slices of another Scotch granite, that of Hildesay, in his private collection, in which a precisely similar mineral to that in the Lairg rock occurs, which he had previously suspected to be allanite. The mineral in these two rocks are clearly identical, and the description of one would do for the other. Extinction in one of Mr. Teall's crystals is nearly straight, showing elongation approximately parallel to the orthopinacoid, but in other crystals it varies, being generally about 34°. One of the crystals shows the zonal structure well.

In the Hildesay granite the allanite is associated with much epidote, but this mineral does not appear to be present in the Lairg rock. My slice contains none, and I have not observed any among the crushed fragments.

The allanite of the Lairg hornblende-granite appears to be an original constituent; it is corroded by the quartz of the groundmass, and it encloses numerous micro-crystals which appear to represent two mineral species; but they are too minute for exact determination.

The Lairg mineral fuses easily in the flame of a Bunsen burner, but is very slightly attacked by hydrochloric or by nitric acids. When ground to a fine powder it yields on prolonged heating to *aqua regia*.

On all the points noted above, the Lairg mineral agrees with allanite; and as I know of no other mineral which, on all points, fits the above evidence, I do not see room for doubt regarding its identification.

In the future, varieties of allanite will no doubt be distinguished from one another, the varieties being dependent on the proportion of the rare metals, and also on the proportion of manganese present in them; but the accurate determination of them will be no easy matter. The collection of material, for instance, from the Lairg rock, is a work of labour; and when obtained, the microscopic fragments are found under high powers to be stuffed full of endo-minerals.

III.—GLACIATED VALLEYS IN THE CUILLINS, SKYE.

By ALFRED HARKER, M.A., F.G.S., of H.M. Geological Survey of Scotland.

(Communicated by permission of the Director-General.)

MANY geologists have recognized that valleys, which have once been occupied by large glaciers, exhibit peculiarities which can only be ascribed to glacial erosion modifying the earlier water-worn form of the land-surface. Indeed, anyone who allows ice-action to be locally a factor of importance in erosion, must expect that the resulting topographical forms will differ in some measure from those proper to water-erosion. Not only does ice, in virtue of its physical properties, obey different laws as regards pressure and flow, but, what is of equal importance, it fills the whole valley instead of following certain narrow channels. We may hope that, just as Gilbert and others have worked out the principles of water-erosion, so the much more difficult problem of ice-erosion may some day be reduced to analysis. An attempt in this direction has been made by McGee in a paper on "Glacial Cañons,"[1] which, however, I cite here rather for its brief summary of the observed characteristics of glaciated valleys.

The object of the present note is merely to draw attention to a district in which these characteristics are exhibited in their most typical form. This is due to two facts. Firstly, the mountain-group of the Cuillins is wholly carved out from a single rock (gabbro), so that all complication arising from the juxtaposition of harder and softer materials is eliminated. Secondly, there are none of the difficulties which attach to a district once overridden by foreign ice. The glaciation of the Cuillins was entirely local, and, although the ice passed over some of the lower watersheds, the flow in the main valleys was always in the natural direction. Further, the topographical forms are not only of a simple order, but are also very clearly exposed. In the mountain tract the drift is never thick enough to obscure the shape of the ground, and the higher valleys, like the mountains themselves, show nothing but naked rock. Since the erosion under existing conditions is a negligeable quantity, we have the forms of the valleys displayed practically as they were left by the ice.

The chief characteristics of the valleys in the Cuillins are summarily as follows. It is important to notice that, while some of them (*e.g.* rock-basins) belong to glacial erosion only, others consis in the exaggeration of features which may be found in some degree in non-glaciated valleys. These are therefore not capable of precise formulation without some kind of quantitative expression, but they are very conspicuous on the ground, and come out clearly in profile sections drawn to true scale.

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[1] Journal of Geology, vol. ii (1894), pp. 350-364.

(i) The valleys always tend in cross-section to the U rather than the V form.

(ii) This tendency is most marked in the upper parts of the valleys (Fig. 1).

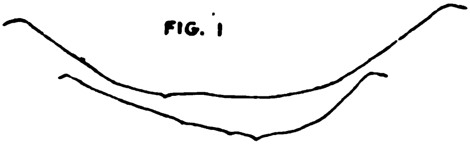

Fig. 1.—Two transverse sections across the upper and lower portions of Coir' a' Ghreadaidh respectively, viz., from the summit of Sgùrr Thuilm to that of Sgùrr na Banachdich, and from the western end of the Thuilm ridge to An Diallaid.

(iii) The head of a valley is usually expanded into a circular amphitheatre. This is the typical 'corrie' (equivalent to 'cwm' and 'cirque'), though this term is currently applied to a valley of almost any form.

(iv) In the centre of such amphitheatre there may be a shallow circular rock-basin occupied by a mountain-tarn.

(v) In one case (Coruisk) there is a deeper and more elongated rock-basin in the lower and narrower part of the valley. Loch Coruisk is a little over a mile in length, and less than one-sixth of a mile in width. The surface is 26 feet above O.D. and the rocky bottom of the stream at the outlet only a few inches lower. The greatest depth sounded[1] is 96 feet, which occurs somewhat nearer to the head than to the foot of the lake and only about 80 yards from the north-east shore, from which the hills rise steeply (Fig. 3). Rocky islets occur near the middle and near the foot of the lake.

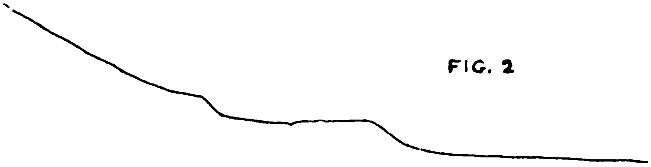

Fig. 2.—Longitudinal section down the valley made up of Lota and Harta Corries, beginning at Bealach an Bhasteir.

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[1] The soundings were taken by members of the Scottish Mountaineering Club, and are marked on the reduced Ordnance Map accompanying No. 25 of the S.M.C. Journal, January, 1898.

(vi) In longitudinal profile the floor of a valley often consists of two or three stretches of relatively gentle slope separated by precipitous drops (Fig. 2). These features are not related to anything in the geological structure of the ground, and the levels are not the same in adjacent valleys.

(vii) A tributary valley debouches at a considerably higher level than the floor of the main valley, so that it terminates in a precipitous drop. This is true not only of the smaller tributary valleys but also of glens of considerable size (e.g. Tairneilear at its junction with Coir' a' Mhadaidh). The point sometimes comes out more clearly if we regard the lines of ice-drainage instead of the present watercourses. Thus the stream from Garbh-choire, the lower part of which is shown in Fig. 3, turns eastward to fall into the sea in Loch Scavaig, but in one stage of the glaciation the ice-drainage was partly over the low watershed into Coruisk.

FIG. 3

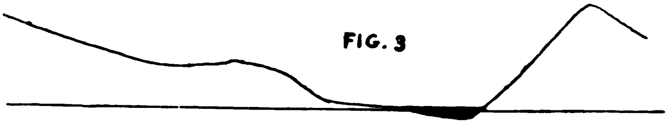


FIG. 3.—Section down the lower part of Garbh-choire and across Loch Coruisk at its deepest part.

Other features might be enumerated, but they appear to arise merely from the co-operation of the several conditions implied in the preceding paragraphs. Thus we find circular amphitheatres enclosed by steep slopes and isolated by precipitous drops from the valleys into which they drain. Where such a corrie occurs at the head of an important valley (e.g. Coir' a' Ghrundda), it falls under the heads (iii) and (vi). Where it overlooks the side of a main valley (e.g. Coir' an Lochain, Fig. 4), it falls under (iii) and (vii).

FIG. 4

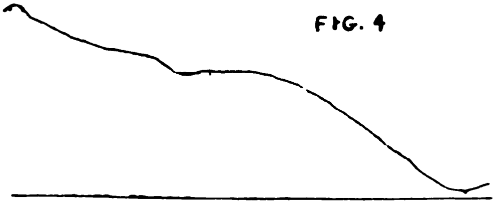
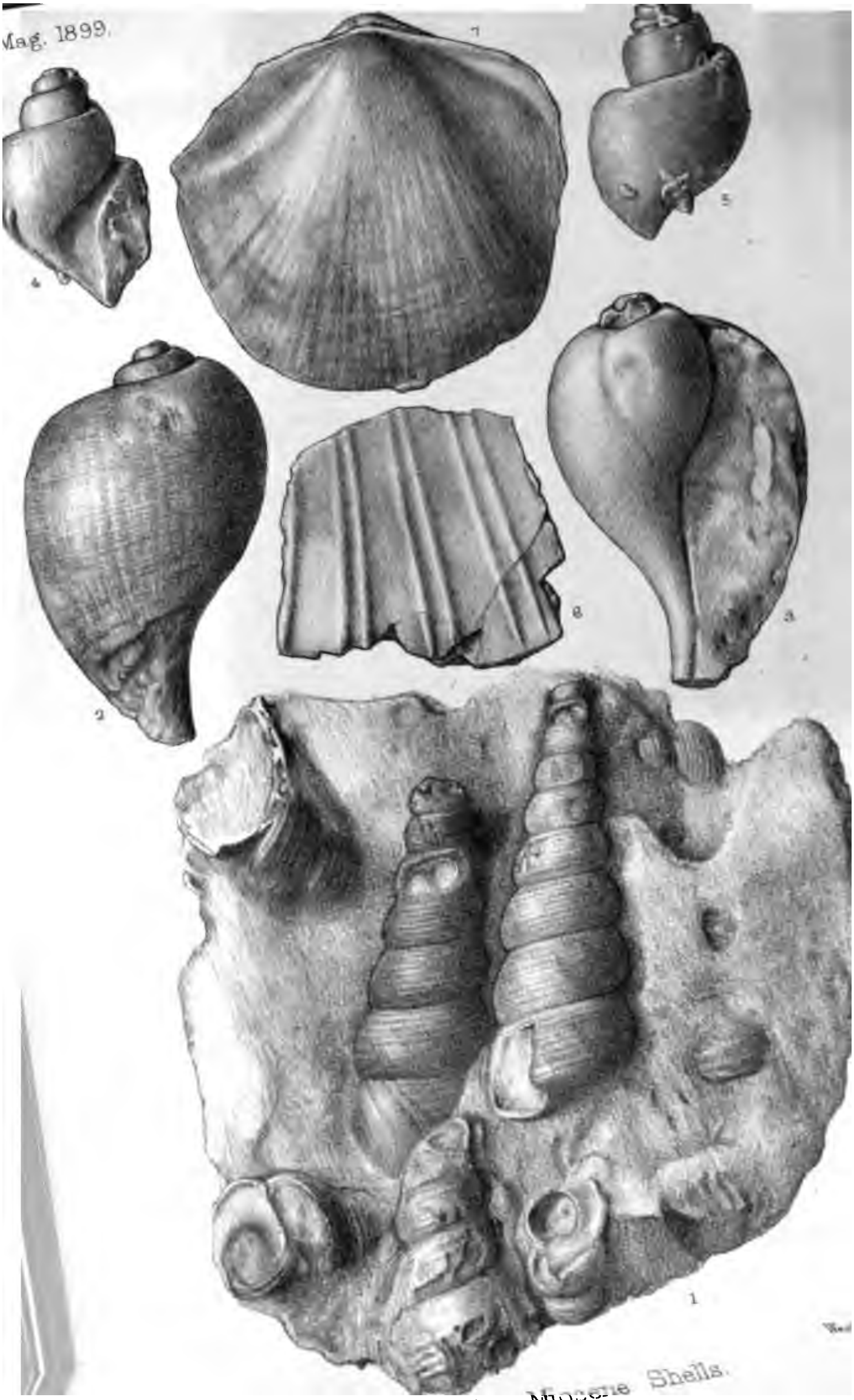


FIG. 4.—Section down Coir' an Lochain (from the Bealach from Coir' a' Ghrundda) through the tarn and down to the Coruisk valley.

In like manner other scenic features of the district are found to resolve themselves into the elementary forms already set forth above, and these seem therefore to embody all that is characteristic of a glaciated valley-system in its simplest development. If so, they afford at the same time the tests by which any synthetic theory of the mechanics of ice-erosion must be tried, but such theory is, as has been remarked, still a desideratum. McGee's treatment of the problem, referred to above, labours under the drawback that it too



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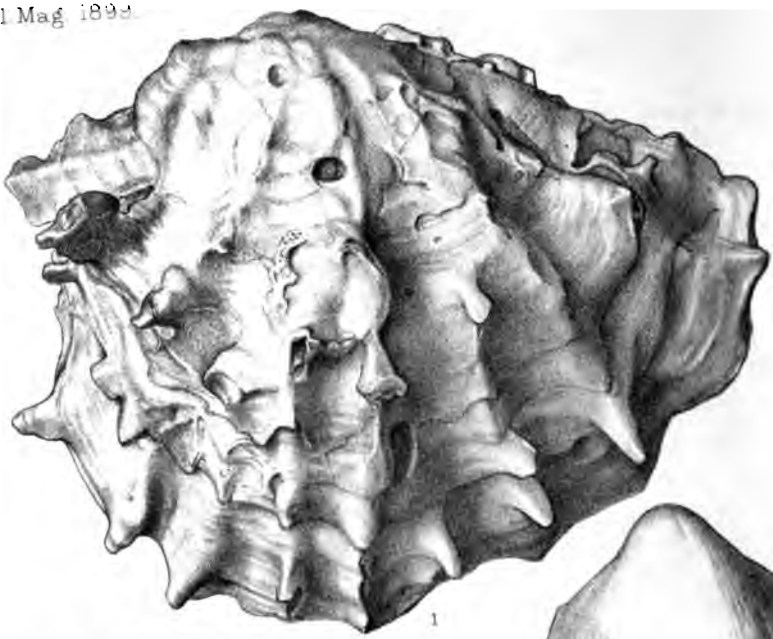
Egyptian Miocene Shells.



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often involves conflicting elements, the relative value of which is a matter of uncertainty.

The figures given in illustration of the above observations are profile sections drawn very roughly to true scale (two inches to a mile). Where a section is drawn longitudinally down a valley, it is not always taken along a straight line, but is made to follow the more important bends of the valley. The horizontal line in each figure represents the sea-level (O.D.).

IV.—NOTES ON SOME MARINE MIOCENE SHELLS FROM EGYPT.

By R. BULLEN NEWTON, F.G.S.

(PLATES VIII AND IX.)

THE marine Miocene shells from Egypt referred to in this paper form part of the collection of Egyptian fossils sent to the British Museum for determination by Captain H. G. Lyons, R.E., F.G.S., Director-General of the Geological Survey of Egypt.

Several writers have contributed lists of marine molluscan species occurring in the different Miocene areas of Egypt—the Siwa Oasis, the Pyramids, Jebel Geneffe, Chalouff, and the coast of the Bitter Lake—among whom may be mentioned, A. B. Orlebar,[1] Oscar Fraas,[2] Ch. Laurent,[3] Gerhard Rohlfs,[4] L. Lartet,[5] and Mayer-Eymar,[6] but for the most complete treatise on this subject we are indebted to Dr. Theodor Fuchs,[7] whose principal investigations were published in the *Palæontographica* for 1883.

Dr. Fuchs' interesting comparisons between the marine Miocene shells of Egypt and those of the Vienna Basin enabled him to establish the fact that a large number of the species were common to both areas; a result more particularly noticeable when comparing the "Grunden Schichten" (= Helvetian) forms with those of the Siwa Oasis, although certain other species were regarded as analogous to those found in the "Horner Schichten" (= Oligocene—Aquitanian stage) and "Steinabrunner Schichten" (= Miocene—Tortonian stage) of the same Basin. The present collection appears to contain representatives of the three lower stages of the Miocene system, no true characteristic Oligocene forms having been determined, viz.:—

MIOCENE { Tortonian.
Helvetian.
Burdigalian (= Langhian).

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[1] "Some Observations on the Geology of the Egyptian Desert": Journ. Bombay Branch Roy. Asiatic Soc., 1846, No. x, pp. 229-250; 14 plates of fossils.

[2] "Aus dem Orient: Geologische Beobachtungen am Nil, auf der Sinai-Halbinsel, und in Syrien," 1867, pp. 157-173.

[3] "Essai Géol. sur les terrains de l'Isthme Suez": Annuaire Soc. anciens élèves Écoles, Arts, Métiers, 1870, p. 230.

[4] "Von Tripolis nach Alexandrien," 1871, vol. ii, pl. iv.

[5] "Essai Géol. Palestine, l'E'gypte, et l'Arabie," pt. ii, Paléontologie: Biblioth. Hautes E'tudes Sci. Nat., vol. vii (1873), No. 2, pp. 48, 73.

[6] "Zur Geologie Egyptens": Viert. Nat. Ges. Zürich, vol. xxxi (1886), pp. 263-5.

[7] "Die Geologische Beschaffenheit der Landenge von Suez": Denk. Akad. Wiss. Wien., vol. xxxviii (1878), pt. 2, pp. 36-8. In Zittel's memoir, "Ueber den Geologischen Bau der libyschen Wüste," 1880, pp. 41-5. "Beiträge Kenntniss Miocaenfauna Aegyptens und der libyschen Wüste" (in Zittel's work on Egypt): Palæontographica, vol. xxx *(1883), pp. 19-66* (or pp. 1-48), pls. vi-xiii (i-viii) and xix-xxii *(xiv-xvii).*

It remains to be stated that the majority of the specimens in this collection were obtained from various places comprised in a tract of country lying between Cairo and Suez, which are referred to as 'Camps,' each one being numbered and having the following geographical position:—

Camps.	Latitude.	Longitude.
No. 6	29° 57′ 40″ N.	31° 44′ 30″ E.
No. 9	30° 10′ 15″	31° 45′ 20″
No. 19	30° 16′ 30″	31° 54′ 40″
No. 21	30° 8′ 40″	31° 56′ 40″
No. 22	30° 15′ 30″	32° 2′ 10″

The additional localities recorded for two of the species are: W. of Jebel Zait, off the Gulf of Suez, and Jebel Geneffe, near Suez.

MOLLUSCA : GASTEROPODA.

Genus TUGURIUM, P. Fischer.

Kiener & Fischer: Spécies Coquilles Vivantes (*Calcar*, *Trochus*, etc.), 1880, p. 450; Fischer's Manuel Conchyliologie, 1885, p. 760.

Type.—*Trochus Indicus*, Gmelin.

TUGURIUM BORSONI, Sismonda, sp.

Phorus gigas, Michelotti: Desc. Foss. Miocènes Italie, Sept., 1847, p. 175, pl. vii, fig. 1 (non *Trochus gigas*, Borson, 1821).

Phorus Borsoni, Sismonda (Bellardi MS.): Synopsis Pedemontii Fossilium, 2nd ed. (1847), p. 50.

Tugurium Borsoni, var. *pagodæformis*, Sacco: Moll. Terz. Piemonte, 1896, pt. xx, p. 27, pl. iv, figs. 4, 5.

Description.—*Testa conica, libera, umbilicata; anfractibus planis, infundibuliformibus, basi repanda; periphæria rotundata; umbilico parvo; apertura trigona.* (Michelotti.)

Dimensions.—Height, (about) 40 millimètres; diameter of base, 40 millimètres.

Some conical limestone casts contained in this collection appear to be referable to this species. They possess about five or six wide, depressed whorls, deeply sutured, of infundibuliform arrangement, and obtusely acute at the periphery; the base is concave and prominently umbilicated; surface exhibiting no sculpture. One of the specimens has some foreign material (small bivalve shells) agglutinated to the spire in the neighbourhood of the suture. This character, together with its perforated base, would indicate its relationship to Fischer's *Tugurium*, in which genus it is here placed. From a comparison of the published figures of this species, especially those last issued by Sacco, there is little doubt that these Egyptian casts may be safely referred to the Italian species which characterizes the Helvetian division of the Miocene of that country. The *Trochus gigas* of Borson, at one time confused with this species, belongs to *Pleurotomaria*.

Horizon.—Miocene (Helvetian).

Distribution.—North Italy; Egypt, between Camps 19 and 22. *Coll. Geol. Surv.* Egypt, No. 815, Box No. 4c.

Genus TURRITELLA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 74.

Type.—*Turbo terebra*, Linnæus.

TURRITELLA TEREBRALIS, Lamarck. (Pl. VIII, Fig. 1.)

Turritella terebralis, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 59. Basterot, "Desc. Tert. Sud-Ouest France": Mém. Soc. Hist. Nat. Paris, vol. ii (1825), pt. i, p. 28, pl. i, fig. 14. Lartet, "Essai Géol. Palestine, l'E'gypte, et l'Arabie," pt. ii, Paléontologie: Biblioth. Hautes E'tudes Sci. Nat., vol. vii (1873), No. 2, p. 48. Sacco: Moll. Terz. Piemonte, 1895, pt. xix, p. 8.

Description.—*Testa elongato-turrita, transversim striata; striis confertis æqualibus; anfractibus medio convexis, basi apiceque depressis; suturis infra marginatis.* (Lamarck.)

Remarks.—As far as detail is concerned the Egyptian examples of this shell are well preserved, although none of them are quite perfect. The main characters of the species as given originally by Lamarck include its elongate, turreted form, the basal and apical depression of the nearly centrally inflated whorls, the regular, elevated spiral striæ forming its sculpture, with no evidence of longitudinal striations, and the possession of a prominent suture. The basal margin of each whorl extends obliquely to the suture. The spiral angle of 13° agrees with the type figured by Basterot from the neighbourhood of Bordeaux.

Horizon.—Miocene (Helvetian).

Distribution.—Bordeaux; N. Italy. Egypt: Jebel Geneffe (Lartet); Camp 22 (= 23*a*); Jebel Geneffe, Suez Canal (5*c*). Coll. Geol. Surv. Egypt, No. 328, Box No. 23*a*; No. 990, Box No. 5*c*.

Genus STROMBUS, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 742.

Type.—*S. pugilis*, Linnæus.

STROMBUS NODOSUS, Borson, sp.

Mitra nodosa, Borson, "Saggio Orittog. Piemontese": Mem. R. Ac. Sci. Torino, vol. xxv (1820), p. 208, pl. i, fig. 9.

Strombus Bonelli, Brongniart: Mém. Terr. Calc.-Trapp. Vicentin, 1823, p. 74, pl. vi, fig. 6. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. Geol. Reichs., vol. iii (1852), p. 189, pl. xvii, figs. 2–6.

Strombus, sp. (cf. *Bonelli*), Fuchs: Palæontographica, vol. xxx (1883), p. 36 (18), pl. vi (i), fig. 4.

Strombus nodosus, Sacco: Moll. Terz. Piemonte, 1893, pt. xiv, p. 4.

Description.—Species having an elongate, narrow, oblong, subcylindrical test, ornamented with transverse sulcations; whorls convex, divided by a deep suture and bearing nodular plications in the centre; last whorl with a ring of large prominent tubercles in the upper part, beneath being (in old forms) some minor tubercles separated by spiral sulcations; aperture elongate, subequal; labrum thick and smooth within; base curved in adult forms; canal very short; columella smooth.

Dimensions (of medium-sized specimen).—Length, (about) 50 mm.; diameter, 30 mm.

Remarks.—The specimens referred to this species are limestone casts, but possessing certain definite characters which suffice for their determination. Both young and adult examples are represented. The narrow, elongate form, its long and deeply sutured spire, with the centrally nodular plications, as well as the spiral striæ, or sulci, ornamenting the surface, serve to distinguish it from *S. coronatus*, Defrance, a closely related species. *S. coronatus* is a shorter and much wider shell with a sharp conical spire, consisting of depressed whorls feebly sutured. Fuchs has figured a similar cast from Egypt under the name of *Strombus* cf. *Bonelli*, but the present examples exhibit rather more clearly the sculpture of the species. Hoernes and Sacco must be referred to for a longer synonymy of this species than is offered here; it is important to notice that Sacco has united *S. Bonelli* of Brongniart, which is an adult form, with the present species.

Horizon.—Miocene (Helvetian).

Distribution.—North Italy; Bordeaux; Vienna Basin; Switzerland, etc. Egypt: Oasis Siwa (Fuchs); between Camps 19 and 22. Coll. Geol. Surv. Egypt, No. 833, Box No. 3*c*.

Genus PYRULA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 73.

Type.—*Bulla ficus*, Linnæus. (Syn. *Ficula*, Swainson.)

PYRULA CONDITA, Brongniart. (Pl. VIII, Figs. 2, 3.)

Pyrula condita, Brongniart: Mém. Terr. Calc.-Trapp. Vicentin, 1823, p. 75, pl. vi, fig. 4. Sowerby (G. B.): Quart. Journ. Geol. Soc., vol. iii (1847), p. 415. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. Geol. Reichs., vol. iii (1853), p. 270, pl. xxviii, figs. 4–6.

Ficula condita, Sacco: Moll. Terz. Piemonte, etc., 1891, pt. viii, p. 23, pl. i, fig. 27.

Description.—*Testa ficoidea, cancellata; striis transversis erectiusculis; interstitiis longitudinalibus, frequentibus, decussantibus; spira brevissima, plano-retusa, centro mucronata; apertura oblonga.* (Hoernes.)

The diagnosis of this species, given here, is that taken from Hoernes' work, which, on account of being somewhat fuller, is thought to be of more practical use than the original as drawn up by Brongniart.

Remarks.—Several casts in the collection evidently belong to this species. They exhibit the smooth arcuate columella, an oblong fusoid aperture, a depressed spire, and an elongate terminal area. The ornamentation, although obscure, is seen to consist of a cancellated structure made up of close longitudinal striations crossed by strong, elevated spiral ridges with finer striæ between each. These specimens have been compared with some beautiful examples of the species in the British Museum from Saucats, S.W. of France, and are found to agree in all essential details.

The species differs from *P. reticulata* of Lamarck in possessing a more delicately arched columella and in its finely cancellate sculpture. The specimen numbered 58*a* appears to be a very old form of this species.

Dimensions.—Length, 55 mm.; width, 35 mm.

Horizon.—Miocene (Helvetian).

Distribution.—Turin: S.W. France; Vienna Basin; Portugal (Sowerby), etc. Egypt: between Camps 19 and 22 (1*c*), and

Camp 22 (58*a*). Coll. Geol. Surv. Egypt, No. 816, Box No. 1*c*; No. 326, Box No. 58*a*.

GENUS DELPHINULA, Lamarck.

Annales Muséum Paris, vol. iv (1804), p. 108.

TYPE.—*Turbo delphinus*, Linnæus.

(?) DELPHINULA, sp.

REMARKS.—The two specimens referred doubtfully to this genus have very convex whorls and a slit-like perforation at the base of the columella; the aperture is large, oval, and acuminate anteriorly; no sculpture can be traced, and no further identification of the specimens is possible.

DIMENSIONS.—Height, (about) 50 mm.; diameter, 45 mm.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Egypt: between Camps 19 and 22. Coll. Geol. Surv. Egypt, No. 817, Box No. 46*c*.

Genus CANCELLARIA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 71.

TYPE.—*Voluta reticulata*, Linnæus.

CANCELLARIA, sp. (Pl. VIII, Figs. 4, 5.)

REMARKS.—Two limestone casts appear to belong to this genus. They have convex whorls, an elongate turreted spire, a subcanaliculation at the base, and an oval aperture pointed anteriorly. In this last character and their form generally they are doubtless related to *C. acutangula* of Faujas-de-Saint-Fond, a species common to the Miocene beds of Bordeaux, N. Italy, Corsica, etc.

DIMENSIONS.—Length, 34 mm.; diameter, 22 mm.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Egypt: between Camps 19 and 22. Coll. Geol. Surv. Egypt, No. 833, Box No. $3^x c$.

MOLLUSCA: LAMELLIBRANCHIATA.

Genus OSTREA, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 696.

TYPE.—*O. edulis*, Linnæus.

OSTREA DIGITATA, Eichw., var. ROHLFSI, Fuchs.

Ostrea digitata, Eichwald: Natur. Skizze Lithauen Volhynien und Podolien, 1830, p. 213.

Ostrea digitalina, Du Bois de Montpéreux: Conchiologie Foss. Wolhyni-Podolien, 1831, p. 74, pl. viii, figs. 13, 14.

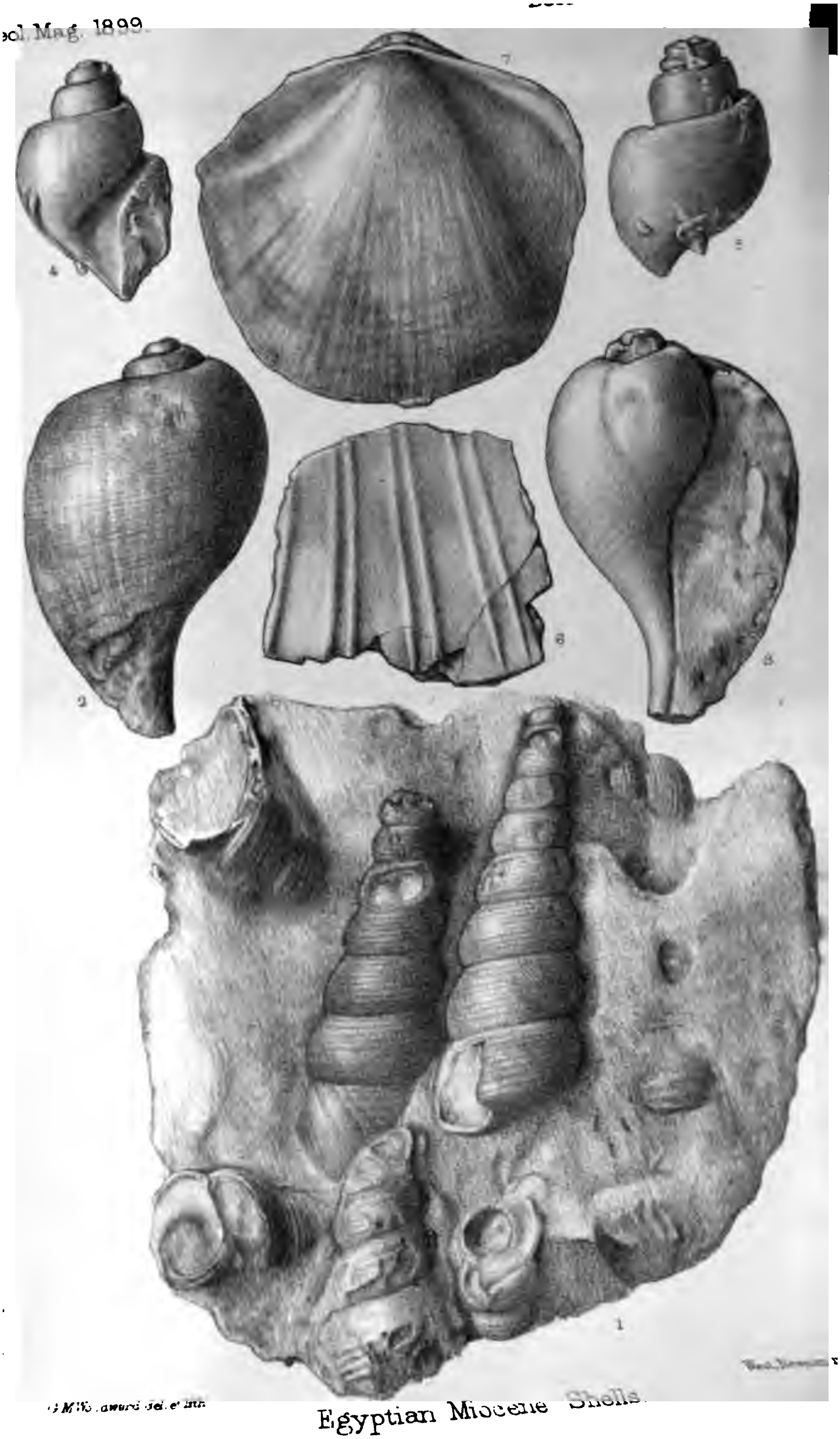
Ostracit, Rohlfs: Von Tripolis nach Alexandrien, vol. ii (1871), pl. iv, fig. 1 (no text).

Ostrea Rohlfsi, T. Fuchs: Denk. Akad. Wiss. (Wien), vol. xli (1879), p. 106, pl. vi, figs. 5–8.

Ostrea digitalina, var. *Rohlfsi*, T. Fuchs: Palæontographica, vol. xxx (1883), pp. 44 (26), 56 (37), 61 (43); pl. xii (vii), figs. 3–6; pl. xxii (xvii), figs. 1–3.

? *Ostrea digitalina*, Mayer-Eymar: ibid., p. 74 (8).

REMARKS.—Although belonging to the group of oysters characterized by *O. digitata* of Eichwald (misspelt *O. digitalina* by most authors), this form exhibits some differences, especially in sculpture, which require the adoption of the composite determination introduced by Fuchs, as *O. digitata*, var. *Rohlfsi*. Probably a new name would have been preferable for the Egyptian shell, for, while agreeing with



G.M.Woodward del. et lith.

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Egyptian Miocene Shells.

plications elevated, few, squamose, irregularly radiate, and obsolete near ventral region in aged examples; ligamental fossula of lower valve moderately excavated and less perceptible in the upper valve.

Dimensions (of an adult valve).—Height, 135 mm.; length, 95 mm.; diameter, 50 mm.

Remarks.—Several of the present specimens are exceedingly thick and coarse, whilst the ligamental areas and muscular scars are of great size. Fuchs recognizes *O. pseudo-edulis* and *O. excavata* as synonymous with *O. Virleti*, the three species being somewhat difficult to separate from each other.

Horizon.—Miocene (Tortonian).

Distribution.—Morea (Deshayes); Russian Armenia (Abich); Persia (Fuchs). Egypt: Siwa and Jebel Geneffe (Fuchs); south of Middle Station, Old Suez Railway (24*a*); Camp 19 (13ª *a*) Camp 21 (12*a*). Coll. Geol. Surv. Egypt, No. 360, Box No. 12*a* No. 342, Box No. 13ª *a*; No. 625, Box No. 24*a*.

Genus PECTEN, O. F. Müller.

Zool. Danicæ Prod., 1776, p. xxxi.

Type.—*Ostrea maxima*, Linnæus.

PECTEN ACUTICOSTATUS, G. B. Sowerby.

Pecten acuticostatus, G. B. Sowerby: Quart. Journ. Geol. Soc., vol. iii (1847), p. 4[illegible], pl. xvii, fig. 18.

Janira lævicostata, Seguenza, "Form. Tert. Reggio (Calabria)": Atti R. A[illegible]e. Lincei, ser. III, vol. vi (1879), p. 188, pl. xiv, fig. 16.

Pecten acuticostatus, Fuchs: Palæontographica, vol. xxx (1883), p. 41 (23), pl. v[illegible]ii (iii), figs. 1–6.

Description.—*P. testa suborbiculari, valva altera convexa, costis radiantibus 20, acutis, elevatis; lateribus costarum interstitiisque concentrice striatis; auriculis magnis, tenuiter radiatim costatis.* (G. B. Sowerby.)

Remarks.—The above constitutes the original diagnosis of this species, which was drawn up from a fragmentary lower valve found in the Tertiary deposits of Portugal (Tagus district). An examination of the type in the Geological Society's Museum proves that some valves in the Egyptian collection can with safety be regarded as this species. A series of elevated triangular ribs, with wide interstitial spaces ornamented by fine concentric striæ, appear to distinguish the shell from other forms. Similar structures characterize *P. lævicostata* of Seguenza from Italian Pliocene (Zanclean) beds, and therefore it may be included as a synonym of Sowerby's older name.

Dimensions (of largest convex valve).—Height, 70 mm.; length, 75 mm.; diameter, 15 mm.

Horizon.—Miocene (Tortonian).

Distribution.—Tagus Beds of Portugal (Sowerby); Southern Italy (Seguenza). Egypt: Siwa and Geneffe (Fuchs); Camp 22 (26^{xxx} *a*) and probably from Camp 21 (20*a*). Coll. Geol. Surv. Egypt, No. 365, Box No. 20*a*; No. 324, Box No. 26^{xxx} *a*.

PECTEN ADUNCUS, Eichwald.

Pecten aduncus, Eichwald: Natur. Skizze Lithauen, Volkynien, und Podolien, 1830, p. 213.

Pecten Josslingi, G. B. Sowerby: Quart. Journ. Geol. Soc., vol. iii (1847), p. 419, pl. xvi, figs. 10–12.

Pecten convexo-costatus, Abich, "Ueber Steinsalz, etc., Russischen Armenien": Mém. Ac. Imp. Sci. St. Pétersbourg, sér. vi, vol. ix (1859), pt. 1, p. 118, pl. i, fig. 4.

Pecten aduncus, Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1867), p. 401, pl. lix, figs. 7–9. Fuchs: Palæontographica, vol. xxx (1883), p. 36 (54), pl. xix (xiv), figs. 1–5.

Description.—Species with very convex lower valve and a rounded, incurved umbone; costæ about 17, rounded, wide, smooth, and separated by conspicuous sulci, or grooves, which are ornamented with fine concentric striations; upper valve flat, with 12 narrow costæ, more or less obsolete at the umbone.

Dimensions (of larger upper valve).—Height and length, 40 mm.

Remarks.—Two upper valves of this species are contained in the collection, the larger having its inner surface covered with parasitic annelid tubes and a bryozoan (*Cellepora*).

Horizon.—Miocene (Helvetian).

Distribution.—Poland (Eichwald); near Lisbon (G. B. Sowerby); Russian Armenia (Abich); Vienna Basin (Hoernes). Egypt: Nile Valley (Fuchs); Camp 22. Coll. Geol. Surv. Egypt, No. 324, Box No. 26^{xxxx} *a*.

PECTEN BEUDANTI, Basterot.

Pecten Beudanti, Basterot, "Desc. Tert. Sud-Ouest France": Mém. Soc. Hist. Nat. Paris, vol. ii (1825), pt. 1, p. 74, pl. v, figs. 1*a–c*. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1867), p. 399, pl. lix, figs. 1–3. Sacco: Moll. Terz. Piemonte, etc., 1897, pt. xxiv (Pectinidæ), p. 62, pl. xx, figs. 1–8.

Description.—Species characterized by its valves bearing very elevated, rounded, and radial costæ (14–16), ornamented with fine, closely-set, regular, lamellose, and transverse striæ. The lower valve is very convex, furnished with an incurved umbone, a moderately short cardinal line having vertically striated auricles of apparently equal size; the upper valve is flat and sometimes rather concave.

Dimensions (of largest lower valve).—Height, 85 mm.; length, 95 mm.; diameter, 20 mm.

Remarks.—This species need not be confused with either *P. solarium* of Lamarck or *P. Tournali*, which are forms of somewhat similar ornament, but possessing a convexity in both valves. Sacco's examples from Italy, although of rather smaller size and recognized under varietal names, appear to exhibit the general structural features of this species. The occurrence of this shell in Egypt is recorded here for the first time.

Horizon.—Miocene (Helvetian).

Distribution.—Bordeaux; Portugal (Sowerby); Constantine (Coquand); Italy; Switzerland; Vienna Basin. Egypt: Camp 22. Coll. Geol. Surv. Egypt, No. 322, Box No. 14a.

PECTEN CRISTATO-COSTATUS, Sacco.

Pecten cristato-costatus, Sacco: Moll. Terz. Piemonte, etc., 1897, pt. xxiv, p. 6 pl. xxi, figs. 1–7.

DESCRIPTION.—*Testa affinis P. subarcuatus*, Tourn., *sed in valv dextera costæ radiales valde elatiores, strictiores, acutiores, sul triangulares, sulcis profundissimis* (*costis latioribus*) *disjunctæ.* (Sacco.

A single lower valve from Egypt appears to belong to thi species, although the radial costæ become rounder as they reac the ventral margin, and their terminations are ornamented wit extremely fine transverse striæ. In all other characters it i extremely like Sacco's shell. Costæ 18–20.

DIMENSIONS (of a lower valve).—Height, 40 mm.; length, 41 mm. diameter, 11 mm.

REMARKS.—This species is closely related to *Janira benedict* (Lamarck), Fontannnes, from the Pliocene of the Rhône Valle and differs mainly in possessing a greater number of ribs.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Italy. Egypt: Camp 19. Coll. Geol. Sur Egypt, No. 371, Box No. 25ˣ *a*.

PECTEN ESCOFFIERÆ, Fontannes.

Pecten Escoffieræ, Fontannes: Études Tert. Bassin Rhône, 1878, pt. iii, p. 95, pl fig. 1. Fuchs: Palæontographica, vol. xxx (1883), p. 24 (42), pl. viii (ii figs. 9–12.

DESCRIPTION.—Shell small, subtriangular, and with a moderatel convex right valve, bearing about 18 subrotund, elevated costæ the sculpture consists of fine concentric striæ in the grooves, whic striations, which become more remote and lamellar near the margin.

DIMENSIONS (of best specimen).—Height and length, 50 mm.

REMARKS. — In adopting a subgeneric name, it may be mentioned that Sacco recognizes this shell under *Æquipecten* of Paul Fischer, on account of its similarity to the type, *P. opercularis.* It is indeed difficult to separate *P. Malvinæ* from the Linnæan species, except that it is somewhat less circular and fan-shaped. Hoernes' work must be referred to for a longer synonymy of the species than is here offered.

HORIZON —Miocene (Tortonian).

DISTRIBUTION.—Poland; Vienna Basin; Touraine; Italy; Persia (Fuchs). Egypt: Jebel Geneffe (Fuchs); no locality recorded for the present Egyptian specimens. Coll. Geol. Surv. Egypt, No. 624, Box No. 22*a*.

PECTEN (ÆQUIPECTEN) ZITTELI, Fuchs.

Pecten Zitteli, Fuchs: Palæontographica, vol. xxx (1883), p. 41 (23), pl. vii (ii), figs. 1-12.

Æquipecten Zitteli, Sacco: Moll. Terz. Piemonte, etc., 1897, pt. xxiv, p. 31.

DESCRIPTION.—Shell suborbicular, furnished with 13-15 broad, radial costæ, and a series of corresponding deep grooves; ribs elevated and subdivided into minor grooves and ridges; ornamentation closely lamellose.

DIMENSIONS (of one valve).—Height, 48 mm.; length, 48 mm; diameter, 10 mm.

REMARKS.—This species belongs to the group of *Pecten opercularis* which Fischer has named *Æquipecten*, and is related to *P. Malvinæ* and *P. cavarium* of Fontannes. The Egyptian examples are in a good state of preservation.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Egypt: Oasis Siwa (Fuchs); Camp 19. Coll. Geol. Surv. Egypt, No. 371, Box No. 25*a*.

PECTEN (AMUSSIOPECTEN) BURDIGALENSIS, Lamarck.

Pecten Burdigalensis, Lamarck: Annales Muséum, vol. viii (1806), p. 355. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1867), p. 418, pl. lxv. Fuchs: Denk. Akad. Wiss. (Wien), vol. xxxviii (1878), pt. 2, p. 37.

Amussiopecten Burdigalensis, Sacco: Moll. Terz. Piemonte, etc., 1897, pt. xxiv, p. 63, pl. xv, figs. 1-7.

DESCRIPTION.—Species of suborbicular shape, with the lower valve more convex than the other; auricles small and of equal size; valves ornamented externally with 12-14 distant, broad, slightly elevated, radial costæ, which are crossed by extremely fine and closely-set concentric striations.

REMARKS.—The Egyptian specimens, although somewhat imperfect, may be readily recognized as this large and well-known species.

DIMENSIONS.—Height, 80 mm.; length, 85 mm.; diameter (both valves in contact), 20 mm.

Sacco's name of *Amussiopecten* was founded to include rather large, but graceful, pectinoid shells, bearing internal costæ and outwardly a series of depressed ribs; both valves being convex and slightly gaping.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Bordeaux; Gironde; Portugal; Sardinia; the Azores; Vienna Basin; Constantine, etc. Egypt: Jebel Geneffe (Fuchs); 9 kilometres S.S.W. of Camp 22. Coll. Geol. Surv. Egypt, No. 355, Box No. 15*a*.

PECTEN, sp.

REMARKS.—Three valves of different pectinoid shells, too imperfect for determination.

HORIZON.—Miocene (Helvetian).

DISTRIBUTION.—Egypt: Camp 22. Coll. Geol. Surv. Egypt, No. 324, Box No. 26^x *a*.

Genus AMUSSIUM [AMUSIUM], Chemnitz.

Conchyl. Cabinet, vol. vii (1784), p. 284, pl. lxi, fig. 595.

TYPE.—*Ostrea pleuronectes*, Linnæus.

AMUSSIUM CRISTATUM, Bronn, sp. (Pl. VIII, Fig. 6.)

Ostrea pleuronectes, Brocchi: Conch. Foss. Subapennina, vol. ii (1814), p. 573 (*non* Linnæus).

Pecten cristatus, Bronn: Zeitsch. Mineralogie (Leonhard), vol. ii (1828), p. 542. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1867), p. 419, pl. lxvi, fig. 1.

Amussium cristatum, Sacco: Moll. Terz. Piemonte, etc., 1897, pt. xxiv, p. 47, pl. xiii, figs. 30, 31; pl. xiv, fig. 1.

Pecten cristatus, Repelin: Bull. Soc. Géol. France, sér. III, vol. xxv (1897), p. 130.

Pecten (*Cornelia*) *cristatus*, Mayer-Eymar: Palæontographica, 1898, vol. xxx, pt. 2, p. 65.

DESCRIPTION.—Shell depressed, nearly orbicular, with a smooth outer surface, and internally possessing 26–32 elevated, radial costæ, which are acuminate and slightly curved at their terminations, and do not quite reach the ventral margin.

REMARKS.—This species is represented in the collection by a single fragment attached to a lower valve of *Pecten acuticostatus*. It is the internal portion of a valve showing three pairs of costal rays with bent acuminate ends, the intervening space between each pair having a maximum width of 9 millimètres. According to Mayer-Eymar this species ranges from Helvetian to Sicilian times in the neighbourhood of the Pyramids.

HORIZON.—Miocene (Tortonian).

DISTRIBUTION.—Vienna Basin; Southern France; Italy; Sicily; Sardinia; Algeria (Repelin), etc. Egypt: probably from Camp 21. Coll. Geol. Surv. Egypt, No. 365, Box No. 20^x *a*.

Genus SPONDYLUS, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 690.

TYPE.—*S. gæderopus*, Linnæus.

SPONDYLUS, sp.

Spondylus, sp., cf. *crassicostatus*, Fuchs: Palæontographica, vol. xxx (1883), p. 25 (43), pl. viii (iii), fig. 14.

DESCRIPTION.—The valves are suborbicular, compressed, and ornamented with fine, closely arranged, tortuous ribs, which separate wider and more prominent costæ having a lamellar or funnel-shaped structure. These larger costæ are broader and less numerous on the right or lower valve than on the left.

Dimensions.—Height, 60 mm.; length, 65 mm.; diameter, 32 mm.

Remarks.—Only one example of this shell is in the collection, consisting of a pair of fragmentary valves *in situ*, though preserving no dorsal characters of any moment and showing merely the slightest indication of one of the lateral auricles. So worn is the specimen that the asperities of the test are a good deal modified, the bases only of the sharp elongate spines, so prominent a feature in recent *Spondyli*, being present. It appears to differ from *S. crassicostatus* in its rounder, more compressed valves and thinner test, and from *S. gæderopus* in the lower valve exhibiting no trace of a foliaceous growth. It probably represents an intermediate form between these two species, which with better material at hand might be worthy of a new specific name. The fragmentary shell figured by Fuchs from Egypt corresponds in most details with the present specimen.

Horizon.—Miocene (Tortonian).

Distribution.— Egypt: Siwa (Fuchs); no locality recorded for this specimen. Coll. Geol. Surv. Egypt, No. 623, Box No. 21*a*.

Genus AXINÆA, Poli.

Testacea Siciliæ, vol. i (1791), p. 32.

Type.—*Arca pilosa*, Linnæus.

AXINÆA PILOSA, Linnæus, sp.

Arca pilosa, Linnæus: Systema Naturæ, 12th ed. (1767), vol. i, pt. 2, p. 1,143, Nos. 181, 182.

Pectunculus glycimeris and *P. pilosa*, Searles Wood, "Mon. Crag Moll. England": Mon. Palæontographical Soc., 1850, p. 66, pl. ix, fig. 1 (*pars*).

Pectunculus pilosus, Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1864), p. 316, pl. xl, figs. 1, 2; pl. xli, figs. 1–10. Seguenza, "Form. Terz. Reggio (Calabria)": Mem. R. Accad. Lincei, ser. iii, vol. vi (1880), pp. 282, 360.

Description.—This is a suborbiculate, equilateral species, convex, and substriated; umbones incurved; margin crenulated. Shell closely related to *Arca glycimeris* of Linnæus, though differing from it in never departing from the regular or equilateral condition; that species being frequently oblique in shape. Searles Wood combined the two under *P. glycimeris*, but more modern authors have treated them as separate species, a plan adopted on the present occasion.

Remarks.—Two examples illustrate this species; they are partial casts showing remnants of the thick test in places. The more perfect one has the valves *in situ*, and exhibits the longitudinal striations together with a series of concentric growth-lines. On the sides are prominent oblique ridges representing the inner margins of the large adductor scars.

Dimensions.—Height, 75 mm.; length, 71 mm.; diameter, 46 mm.

Horizon.—Miocene (Helvetian).

Distribution.—Found recent in the Mediterranean Sea; and fossil in N. and S. Italy; Poland; Morea; S. France; Rhône Basin; near Lisbon; England; Vienna Basin; Azores; Oran, etc. Egypt: Camp 22. Coll. Geol. Surv. Egypt, No. 325, Box No. 57*a*.

Genus CARDIUM, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 678.

Type.—*C. costatum*, Linnæus.

CARDIUM, sp. (Pl. IX, Figs. 3, 4.)

Remarks.—Under this genus are placed three casts of shells with attached valves, which are tumid, oblique, and elongate, and furnished with incurved, anterior, nearly contiguous umbones, beneath being an oval excavation. One of the specimens is covered with obscure vertical ribbing on its left valve, and still more obscure indications of concentric sculpture. An obtuse, postero-median, oblique carination proceeds from the beaks to the ventral region, forming the inner margin of the posterior area. This form appears to be related to *Cardium discrepans*, Basterot, a species common to the Miocene of Southern France, N. Italy, etc.

Dimensions.—Height, 45 mm.; length, 43 mm.; diameter, 30 mm.

Horizon.—Miocene (Tortonian).

Distribution.—Egypt: Camp 9. Coll. Geol. Surv. Egypt, No. 642, Box No. 53*a*.

Genus LUCINA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 84.

Type.—*Venus edentula*, Linnæus.

LUCINA MULTILAMELLATA ?, Deshayes. (Pl. VIII, Fig. 7.)

Lucina multilamellata, Deshayes: Encyclopédie Méthodique, vol. ii (1830), p. 377 (not figured). Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1864), p. 227, pl. xxxiii, fig. 2. Fuchs: Palæontographica, vol. xxx (1883), p. 39 (21), pl. vi (i), fig. 12.

Description.—The Egyptian collection contains a series of casts belonging to a lenticular and suborbicular shell with both valves in contact, which resembles very strongly Fuchs' interpretation of this species as figured by him in the *Palæontographica*. The surface irregularities on the interior of the valves, alluded to by Deshayes in the original description, are well seen in the specimens, besides some obscure indications of radial striæ.

Dimensions.—Height, 52 mm.; length, 54 mm.; diameter, 24 mm.

Horizon.—Miocene (Helvetian).

Distribution.—Bordeaux; Vienna Basin. Egypt: Siwa (Fuchs); between Camps 19 and 22 (2*c*) and S.E. of Camp 19 (48*c*). Coll. Geol. Surv. Egypt, No. 830, Box No. 2*c*; No. 871, Box No. 48*c*.

Genus TELLINA, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 674.

Type.—*T. radiata*, Linnæus.

TELLINA LACUNOSA, Chemnitz.

Tellina lacunosa, Chemnitz: Conchylien-Cabinet, vol. vi (1782), p. 92, pl. ix, fig. 78.
Tellina papyracea, Gmelin: Linnæus' Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,231.
Tellina tumida, Brocchi: Conch. Foss. Subapennina, vol. ii (1814), p. 513, pl. xii, fig. 10.

Tellina lacunosa, Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1859), p. 91, pl. ix, fig. 1. Fuchs: Denk. Akad. Wiss. (Wien), vol. xxxviii (1878), pt. 2, p. 36.

Tellina tumida, Seguenza, "Form. Terz. Reggio (Calabria)": Mem. Atti R. Accad. Lincei, ser. III, vol. vi (1880), p. 73.

Description.—Shell roundly ovate, ventricose, possessing a wide postero-median depression in the right valve and a peculiarly twisted ventral region.

Dimensions.—Height, 48 mm.; length, 53 mm.; diameter, 25 mm.

Remarks.—Represented by some casts exhibiting attached valves, which have been compared with recent examples of this species from Guinea, and found to agree in all essential details. They show the central depression of the right valve, a more inflated left valve, and the typical flexuosity of the ventral area. No scar impressions are visible, but the posterior oblique area, reaching from the beaks to the infero-ventral margin, is well defined. Two valves, Box No. 48^{x} *c*, are doubtfully referred to this species; they may be young forms.

Horizon.—Miocene (Burdigalian).

Distribution.—Recent, from the Guinea Coast; fossil from Italy, Switzerland, South of France, Vienna Basin, etc. Egypt: Jebel Geneffe (Fuchs); Camp 6 (52*a*) and S.E. Camp 19 (48^{x} *c*). Coll. Geol. Surv. Egypt, No. 641, Box No. 52*a*; No. 871, Box No. 48^{x} *c*.

Genus MERETRIX, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 85.

Type.—*Venus meretrix*, Linnæus.

MERETRIX ERYCINA, Linnæus, sp.

Venus erycina, Linnæus: Systema Naturæ, vol. i (1767), pt. 2, p. 1,131.

Cytherea erycinoides, Lamarck: Hist. Nat. Anim. sans Vert., vol. v (1818), p. 581.

Callista erycina, H. & A. Adams: Genera of Recent Mollusca, vol. ii (1857), p. 425.

Cytherea erycina, Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1861), p. 154, pl. xix, figs. 1, 2.

Cytherea erycinoides, Seguenza, "Form. Terz. Reggio (Calabria)": Mem. Atti R. Accad. Lincei, ser. III, vol. vi (1880), pp. 52, 60, 119.

Description.—Shell transversely oval, cuneiform; wide, short, and round anteriorly; round, acuminate, and produced in rear; surface ornamented with depressed concentric sulcations.

Dimensions (valves *in situ*).—Height, 48 mm.; length, 37 mm.; diameter, 23 mm.

Remarks.—The Egyptian specimens referred to this species are somewhat obscure and imperfect, though that from which the above dimensions are taken is in fairly good condition and shows the shape of the shell as well as the typical parallel, obtuse sulcations which ornament its valves. There is a long synonymy to the species which is well set out in Hoernes' work, but not repeated here.

Horizon.—Miocene (Burdigalian).

Distribution.—Bordeaux; North and South Italy; Gironde Basin; Rhône Basin; Portugal; Vienna Basin, etc. Egypt: Camp 6. Coll. Geol. Surv. Egypt, No. 640, Box No. 51*a*.

MERETRIX, allied to HAGENOWI, Dunker, sp.

Cytherea Hagenowi, Dunker: Novitates Conchologicæ, 1865, pt. ii, No. 2, p. 13, pl. iv, figs. 13–15; Zeitschr. Malakozoologie (Menke & Pfeiffer), 1849, p. 184.

Description. — Shell characterized by its rounded posterior margin and rather shallow valves, ornamented with numerous regular, concentric, and rather obsolete plications.

Remarks.—An imperfect right valve contained in this collection appears to be closely allied to this species, and differs chiefly in exhibiting a strongly pronounced concentric sculpture. It, however, compares favourably with a recent specimen from the Red Sea in the British Museum identified as this species.

Dimensions.—Height, 50 mm.; length, 60 mm.; diameter, about 12 mm.

Horizon.—Miocene (Burdigalian).

Distribution. — Egypt: Camp 6. Coll. Geol. Surv. Egypt, No. 640, Box No. 51^{x} *a*.

MERETRIX LAMARCKI, Agassiz, sp.

Cytherea nitidula, Basterot, "Desc. Géol. Tert. Sud-Ouest France": Mém. Soc. Hist. Nat. Paris, vol. ii (1825), pt. 1, p. 91, *non* Lamarck. Goldfuss: Petrefacta Germaniæ, vol. ii (1840), p. 239, pl. cxlix, fig. 11.

Cytherea Lamarcki, Agassiz, "Iconographie Coquilles Tertiaires": Nouv. Mém. Soc. Helvétique Sci. Nat., vol. vii (1845), p. 39, pl. vii, figs. 1–4. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1861), p. 153, pl. xviii, fig. 5.

Description.—Species ovate, transverse, ventricose, inequilateral; wide and round anteriorly and in rear; lunule prominent; posterior area lanceolate; margins closed.

Dimensions.—Height, 44 mm.; length, 56 mm.; diameter, 28 mm.

Remarks.—An internal cast of both valves *in sitû* represents this shell. Its careful comparison with the excellent figures of Agassiz and Hoernes leaves no room for doubt that it belongs to this form. The elegant rounded and ventricose character of this species is well maintained in the specimen.

Horizon.—Miocene (Burdigalian).

Distribution. — Bordeaux; Westphalia; Vienna Basin, etc. Egypt: Camp 6. Coll. Geol. Surv. Egypt, No. 641, Box No. 52^{x} *a*.

[BIVALVE: INDETERMINABLE.]

Remarks. — A badly preserved specimen — not identifiable, but probably belonging to the genus *Meretrix*.

Horizon.—Miocene (Burdigalian).

Distribution. — Egypt: Camp 6. Coll. Geol. Surv. Egypt, No. 640, Box No. 51^{x} *a*.

Genus VENUS, Linnæus.

Systema Naturæ, 10th ed. (1758), p. 684.

Type.—*Venus chione*, Linnæus.

VENUS BURDIGALENSIS ?, Mayer-Eymar.

Venus Burdigalensis, Mayer-Eymar: Journ. Conchyliologie, sér. II, vol. iii (1858), p. 298; ibid., sér. II, vol. iv (1860), pl. v, fig. 4; Syst. Verz. Foss. Reste Madeira, etc., 1864, p. 19. Hoernes, "Foss. Moll. Tert.-Beck. Wien": Abhandl. k. k. geol. Reichs., vol. iv (1861), p. 129, pl. xv, fig. 1.

Remarks.—Three internal casts of a *Venus* with attached valves are referred doubtfully to this species. They are of similar proportionate size to the type, and preserve the same obliquely curved outline of the dorso-posterior area. The lunule is large and deeply excavated, whilst the escutcheon is long, wide, and lanceolate. No pallial impression is seen, and the muscular scars are nearly obsolete.

Dimensions.—Height, 60 mm.; length, 68 mm.; diameter, 38 mm.

Horizon.—Miocene (Burdigalian).

Distribution.—Bordeaux; Vienna Basin; Island of Baixo, Madeira. Egypt: Camp 6. Coll. Geol. Surv. Egypt, No. 1,002, Box No. 47*c*.

VENUS, sp.

Remarks.—Represented by two imperfect casts, which exhibit a deep excavation beneath the beaks corresponding to the lunule; on the other side is a prominent lanceolate depression representing the escutcheon area. A concentric lamellose ornamentation is somewhat obscurely seen in one of the specimens. They are probably the moulds of *Venus plicata*, Gmelin.

Dimensions.—Height, 35 mm.; length, 40 mm.; diameter, 23 mm.

Horizon.—Miocene (Tortonian).

Distribution. — Egypt: Camp 9. Coll. Geol. Surv. Egypt, No. 642, Box No. 53^{x} *a*.

EXPLANATION OF PLATE VIII.

Turritella terebralis, Lamarck. Helvetian of Jebel Geneffe.

Fig. 1.—Several examples on a small slab of yellowish sandstone.

Pyrula condita, Brongniart. Helvetian of Camp 22.

Fig. 2.—Back view of specimen.
Fig. 3.—Front aspect, showing aperture.

Cancellaria, sp. Helvetian: between Camps 19 and 22.

Fig. 4.—Front aspect of shell.
Fig. 5.—Back view of same specimen.

Amussium cristatum, Bronn, sp. Tortonian: probably from Camp 21.

Fig. 6.—Fragment showing the internal surface of a valve and its pairs of costal rays; attached to a valve of *Pecten acuticostatus*.

Lucina multilamellata?, Deshayes. Helvetian: between Camps 19 and 22.

Fig. 7.—Cast of specimen with indications of radial striæ.

EXPLANATION OF PLATE IX.

Ostrea Fuchsiana, sp. nov. Tortonian: from Camp 19.

Fig. 1.—External view of lower valve, exhibiting the radial ridges and spines.
Fig. 2.—Internal view of same specimen, showing small ligamental area and extensive muscular scar.

Cardium, sp. Tortonian: Camp 9.

Fig. 3.—Cast of a specimen showing vertical striation.
Fig. 4.—Umbonal view of same specimen.

[The figures on both Plates are drawn natural size.]

V.—ZONES AND 'CHRONOLOGICAL' MAPS.

By A. J. JUKES-BROWNE, B.A., F.G.S.

MODERN stratigraphical geologists, both those who study the Palæozoic and those who are occupied with the Neozoic rocks, are largely concerned with the establishment of zones; in other words, the zonal method of subdivision has been recognized as the best means of correlating the stratigraphical succession in one area with that of another. But when it comes to giving an exact definition of a zone there does not appear to be the same unanimity of opinion, and consequently it seems desirable that some well-considered definition of a zone should be put forward and discussed.

The conceptions of a zone which have from time to time been expressed by different English writers may, I think, be arranged in two sets, according as they give prominence to one of two different ideas. One set of writers have regarded the essential idea of a zone to be an assemblage of fossils which could be traced over a more or less extended geographical area; other writers consider a zone to be an actual belt or band of stratified rock characterized by a certain number of fossil species.

Most of the earlier English writers on this subject used the term 'zones of life,' and it is probable that this imparted to some minds an erroneous impression that such zones were zoological assemblages or faunas, and were only useful as aids in determining a sequence which was established on a different basis.

Another phrase frequently used was 'Ammonite zones,' which naturally led to the fallacy that zones were established solely on the occurrence of certain species of Ammonites without reference to the distribution of other kinds of fossils.

One of the earliest investigators of zones in this country was Dr. Thomas Wright, and though he makes use of the terms 'life-zones' and 'Ammonite zones,' yet it is quite clear from his writings that by a zone of the Lias he means an actual subdivision of the Lias, a group of beds containing an assemblage of fossils, some of which are restricted to the zone.[1]

Mr. R. Tate, writing in 1867 of Liassic zones, says: "The zone is a zoological one and signifies an assemblage of species, and whether you call it Lias α or Lias β, or the zones of *Ammonites planorbis* and *Ammonites angulatus*, the succession of faunas in the Lower Lias still remains patent, and it is to these several faunas that the term Ammonite zone is applied."[2]

This passage is somewhat confused, for he defines a zone as a fauna, and yet says it might equally well be called Lias α, β, etc., which are stratigraphical subdivisions. In 1875, however, he expresses himself much more clearly, for he writes that "the strata [of the Lias] admit of a grouping into zones after their palæontological characters, and further into regions of Ammonites, a classification as much in harmony with facts as that of the Oolitic rocks into formations."[3]

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[1] Quart. Journ. Geol. Soc., vol. xvi (1860), p. 374; and "The Lias Ammonites," *Mon Pal. Soc.*, 1878–9.

[2] Quart. Journ. Geol. Soc., vol. xxiii, p. 300.

[3] *Quart. Journ.* Geol. Soc., vol. xxxi, p. 493.

The mistaken ideas prevalent between 1860 and 1870 respecting zones are reflected by Mr. C. Moore, who makes some observations on the "value of zones of zoological life," which show that he thought the fauna of a zone was supposed to be strictly confined to it, and he indicates some exceptions to the supposed law.[1]

Professor Phillips seems to have regarded zones as relating to the succession of species belonging to some single order or class; thus, after referring to the useful results obtained from a study of 'Ammonite zones,' he says: "the same method . . . . ought to be applied in all cases of large groups; we should have zones of Echinodermata, Brachiopoda, etc., treated independently of the Cephalopoda, with which they would not necessarily synchronize, and finally all would be combined into a true system of geological chronology."[2] No doubt such a study would be very useful, but the idea of a zone conveyed by Phillips is not that held and expressed by those who were then actually working at zones; it does not even imply a zonal fauna, much less a set of strata identified by such a fauna.

In an earlier publication, however, Phillips seems to have used the term zone in a sense which approaches more closely to its normal signification. He says:[3] "A palæontologist finds the whole Carboniferous Period one, though in it are several zones distinguishable by the prevalence of a few types and by the paucity or absence of others."

It is evident that the men of Phillips' generation were not consistent in their use of the term zone, and that few of them had seen the necessity of formulating a clear definition. Since 1880 this necessity has been more felt, and the value of the zonal method has been more fully recognized. In some quarters, however, there is still a lurking antagonism to it, and a disposition to regard it as a method which is based on a different principle from that which guides ordinary stratigraphical work. I hope, however, to show in the sequel that this is a mistake.

It is curious to find Mr. H. B. Woodward so late as 1892 defining a zone in a zoological and not a stratigraphical sense, and stating that "zones are assemblages of organic remains, of which one abundant and characteristic form is chosen as an index," though in a later paragraph he remarks that "the essential idea of a zone is that it marks a period of time."[4] It is quite true that one essential idea of a zone is that it corresponds to a period of time, but if so, it seems to me that it must also correspond with the depth of sediment formed during that period. This sediment, of course, will vary in depth and character from place to place, but it unquestionably forms a band or zone of sedimentary material, and it must be, to say the least, as correct to define a zone as a band of stratified rock as to call it an assemblage of fossils. This is certainly the view taken by most recent writers.

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[1] Quart. Journ. Geol. Soc., vol. xxiii, p. 510.

[2] "Geology of Oxford," 1879, p. 132.

[3] Quart. Journ. Geol. Soc., *vol. xvi (1860)*, Pres. Add., p. xxxviii.

[4] "On *Geological Zones*": *Proc. Geol. Assoc.*, vol. xii, p. 298.

To select a few out of many authorities the following may b mentioned :—

(1) Professor Lapworth states that *stages* or groups of strat "are divisible into zones or minor groups of strata." See "Introductory Textbook" (Page & Lapworth), 1888, p. 125, and "Intermediate Textbook," 1899, p. 155.

(2) Kayser & Lake, who give the same definition. ("Textboo of Comparative Geology," 1895, p. 6.)

(3) Sir A. Geikie—"Textbook of Geology," first edition (1882) p. 635, and third edition (1893), p. 678—defines a zone as a bed, o a limited number of beds, characterized by one or more distinctiv fossils.

(4) Mr. S. S. Buckman, who remarks: "I take it that of late year the stratum or strata characterized by an assemblage of organi remains, more or less peculiar thereto, has been regarded as a zone. (Quart. Journ. Geol. Soc., xlix, 1893, p. 481.)

(5) Mr. J. E. Marr, who defines zones as "belts of strata, eac of which is characterized by an assemblage of organic remains, o which one abundant and characteristic form is chosen as an index. ("Principles of Stratigraphical Geology," 1899, p. 68.)

In view of this consensus of recent opinion it is surprising to fin that the reviewer of Mr. Marr's book in the GEOLOGICAL MAGAZIN for February dissents from the definition just quoted, and says "Zones must be identified by fossils, and not by the strata; an therefore they serve to indicate periods of time rather than masse of sediment. We could hardly speak of a zone which is represente partly in Upper Greensand, partly in Red Chalk, and partly i Gault Clay as forming a belt of strata" (op. cit., p. 85).

This is not a very lucid statement, but the reviewer evidently objects to a zone being regarded as a definite stratigraphical unit; he is attached to the old lithological method of classification, and does not believe in mapping by fossils. But he should not find fault with Mr. Marr for giving expression to the general belief of the day—and, as we have seen, according to that general belief a zone is a group of strata; further, as a zone literally means a girdle or belt, it is correct to use that word in defining it.

Again, if the same assemblage of fossils can be traced from a Greensand area through a Gault area and into one of Red Chalk, does not that assemblage occupy a belt of strata? The belt may vary in thickness, but that does not matter; it may not only pass laterally from sand to clay, but it may in one district include both sand and clay, and such variation does not make it any the less a band or belt of strata.

The zonal method, in fact, is merely a development of William Smith's original method of identifying formations by means of the organic remains which they contain. Just as one stage is identified and distinguished from others by the assemblage of fossils it contains, so in its turn is the zone identified by its fossils. The stage is not a fauna, but a subdivision of a series or system of strata, and in like *manner the zone* is a subdivision of a stage. The reviewer appears to be quite unaware that this is the accepted view of a zone; he may, of course, still maintain that he is right and that the authorities I have quoted are wrong, but if so, something more satisfactory in the way of argument will be expected from him.

Why, again, should the reviewer deem it impossible to produce such maps as Mr. Marr has expressed a desire to see—maps in which the colours should rigidly signify stages or divisions founded on palæontological evidence, and not in any way on the lithological facies of the rocks. He intimates that the Cretaceous stages of Albian, Cenomanian, etc., could not be mapped in this way, but I have probably had as much experience of these strata as the reviewer, and I will undertake to say that they could be mapped by palæontological evidence, though of course the surveyor would have to know his fossils well to start with.

It is a mistake to suppose that the only kind of geological map which can be of any use is one showing the different kinds of rock which occur in a given district. That is doubtless the kind of map which is best suited for economical purposes, and as such it is the kind of map issued by our Geological Survey and by the Service de la Carte Géologique de la France; but that is, after all, only one kind of geological map. There is certainly another kind, more strictly scientific and just as truly stratigraphical; this may be called a chronological map, though a better term might be found for it, and the smallest division shown by colour on such a map would be a stage, such as Bathonian or Turonian.

There would be no more difficulty in producing a series of such maps than there is in drawing a line between the Gault and the Upper Greensand in Surrey and Hampshire, a task which I commend to the reviewer, and to any geologists who still believe in the exceeding usefulness of such divisions as Gault and Upper Greensand.

As a matter of fact, I am informed by my friend Professor Barrois that the Geological Service of France is actually now issuing such maps; sheets on a scale of $\frac{1}{320000}$, with a system of coloration by stages and showing what we will call the 'solid geology' only, without obscuration by superficial deposits.

When, therefore, Mr. Marr asserts that "for theoretical purposes two sets of chronological maps, one founded upon lithological differences, the other upon differences of fossil organisms, would be extremely valuable,"[1] he should be commended for his foresight, and he will doubtless be glad to know that in one country, at least, the need for such maps has not only been felt but met.

The mapping of zones would be a more difficult matter, though in many cases of well-established zones it could doubtless be done at once; but it is safe to say that in process of time, when the zonal succession in every formation has been more fully studied and fairly well established, the larger zonal divisions or groups of sub-zones could be distinguished on such maps, either by tints of the 'stage' colour or by a system of lettering.

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[1] "Principles of Stratigraphical Geology," pp. 15 and 87.

VI.—On the Average Composition of British Igneous Roc

By Alfred Harker, M.A., F.G.S., Fellow of St. John's College, Cambridg

THE subject of the average composition of collections of ro has been dealt with in a paper published ten years ago Mr. F. W. Clarke on "The Relative Abundance of the Chemi Elements."[1] The object of that paper was to arrive at an estim of the mean chemical composition of the earth's crust, incidentally the author shows a close correspondence betw the mean compositions of groups of miscellaneous rocks fr different regions. It appears from his figures that a moder number of analyses—less than a hundred—if taken without selection, is enough to give value to their mean. It may theref be of interest to apply the method to our own country. I ha accordingly collected published analyses of 397 British igne rocks, viz., 195 English, 31 Welsh, 79 Scottish, and 92 Iri and calculated their mean. By searching it would doubtless possible to find additional analyses, though probably not ma and the number taken is quite sufficient for our purpose. I ha taken all the complete analyses that I found, except a very f known to be faulty, since it is the essence of the statistical meth that no selection should be exercised. Partial analyses I have used, with the exception of 78 analyses of Malvern rocks Timins, in which the alkalies were not estimated. The me given by the 397 analyses (or in the case of the alkalies by 31 appears in Column I.

	I. British Rocks.	II. British Rocks (corrected).	III. American Roc
SiO_2	58·75	58·46	59·77
TiO_2	0·12	0·69	0·53
Al_2O_3	15·64	15·13	15·38
Fe_2O_3	5·34	5·34	2·65
FeO	2·40	2·40	3·35
MnO	0·15	0·40	0·09
MgO	4·09	3·84	4·40
CaO	4·98	4·98	4·81
Na_2O	3·25	3·25	3·61
K_2O	2·74	2·74	2·83
H_2O	2·23	2·23	1·51
P_2O_5	0·02	0·25	0·21
	99·71	99·71	99·14

These figures, however, need some corrections for various reaso In particular, certain constituents have not been determined in cases. Titanic acid was estimated in 30 analyses only and recor as 'traces' in 4 others. The mean for the 34 rocks is 1·39. T is doubtless too high a figure to be inserted in the general avera because titanic acid has usually been sought in such rocks (chie of basic and ultra-basic composition) as were expected to yield in noteworthy quantity. Since some arbitrary assumption necessary, I have halved the figure, and taken the titanic acid as 0·69 per cent. The difference between this and 0·12 is to be subtracted from the silica and alumina, and half has been taken from each. The same reasoning does not apply, at least in the same degree, to manganese and phosphoric acid. Manganous oxide was estimated in 103 analyses and recorded as traces in 51. The mean for these 154 rocks is 0·40, and this figure may be adopted in the general average without fear of much error. The difference between 0·40 and 0·15 is to be subtracted from the magnesia. Phosphoric anhydride was estimated in 35 analyses only and recorded as traces in 20. The mean for these 55 rocks is 0·25, and this figure may be adopted in the general mean, the difference between this and 0·02 being accordingly subtracted from the alumina. The result as thus corrected is seen in column II. In the paper already cited Clarke gives the mean analysis of 880 miscellaneous rocks, American and others; but I quote for comparison, instead of this, a mean analysis of American rocks exclusively, given in a later work by the same author.[1] This, which is calculated from 680 complete analyses, supplemented by a number of partial analyses, is given in column III.

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[1] Bull. Phil. Soc. Washington, vol. xi (1889), pp. 131–142; also in *Chem News for Jan. 17, 1890.*

There are still certain points to be observed in comparing the two columns. In 157 of our 397 analyses ferrous oxide was not estimated. The figure for this constituent is therefore too low and that for ferric oxide correspondingly too high. Again, the water has not always been estimated in the same way. In many of the analyses only the loss on ignition has been determined, and by taking this as water I have no doubt increased unduly the figure for that constituent. Carbonic acid, chlorine, fluorine, and sulphur, when separately estimated in the analyses, have been discarded. These, of which only the first is of importance, are therefore partly included, together with 'loss' and errors, in the 0·29 per cent. required to make up the total to 100. This defect should really be somewhat greater, since a certain amount of ferrous oxide has been reckoned as ferric.

The British mean is seen to have a rather lower silica-percentage than the American, though it agrees closely enough with the figure (58·59) in Clarke's old mean for rocks from various quarters of the globe. The difference is perhaps not a significant one. As regards titanic acid and alumina, the two columns show a fair correspondence. The British rocks are evidently richer in iron than the American. The proportions of the two oxides are, as has been remarked, not correct, and it is not possible to rectify them; but converting the whole to ferric oxide, we get 8·01 for column II, as compared with 6·37 for column III. The relatively high percentage of manganese in the British rocks is certainly of significance, and must be regarded as a characteristic of the whole assemblage. The precise figure is not to be insisted upon, since it has been reached in a rather arbitrary fashion; but even in column I, where all rocks in which manganese had not been recorded were assumed to contain none, the figure is very distinctly higher than Clarke's. We see next th the British rocks are poorer in magnesia, and rather poorer in sod than the American, while in lime and potash the two columns sho no great disparity. The alkalies jointly amount to 5·99 in th one column as compared with 6·44 in the other. We might hav anticipated a greater deficiency in alkalies in the British rocks, an also a more marked excess of lime, as compared with the American since the majority of our rocks belong decidedly to what Iddings ha styled the 'Sub-Alkali' rather than to the 'Alkali' group, while bot groups are well represented in the United States. The apparentl rather large percentage of water in column II must be due in par to the circumstances already noted. In phosphoric acid there is sufficiently close agreement between the two averages.

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[1] Clarke & Hillebrand, *"Analyses of Rocks"*: Bull. 148, U.S.G.S., 1897.

If we were to separate the English, Scottish, and Irish rocks, an calculate averages for the several groups, we should find that thes would be disturbed by principles of selection which have entere into the choice of the rocks analyzed. Thus we have a larg number of analyses of Irish granites by Professor Haughton, whil the Scottish granites have been comparatively neglected. This goe to make the Irish average more acid and the Scottish more basi than the general mean. Nevertheless, it would no doubt be possibl to get results of interest for even smaller areas, provided that rock sufficiently various in kind are included; and, if we take account o partial as well as complete analyses, we shall find for some areas considerable body of data. For example, 96 igneous rocks from th English Lake District give a mean silica-percentage 58·75, not very different from that of the general average; but 82 examples from the Malvern Hills give only 54·81. The low figure in the latte case can scarcely be accidental. It is worthy of note, too, that o 78 igneous rocks from the Malverns, Timins estimated copper oxid in 21 and recorded traces in 11 others, the mean percentage being 0·23 for these 32 rocks, or 0·12 for the whole 78. This is at leas twenty times as great as any probable estimate for the general average of rocks.

The mean specific gravity of a large number of igneous rock from a given district will probably be found in some cases to b characteristic. Of the 397 analysed British rocks included above, specific gravities are given for 209, the mean value being 2·777. By including 527 miscellaneous igneous rocks from various district of Britain, we find the mean specific gravity of the whole 736 to be 2·763. Taking the two special districts already mentioned, we find that 113 Lake District rocks give a mean specific gravity 2·737, decidedly below the average, while 38 from the Malverns give 2·841, which is decidedly above the average. The preponderance of basic rocks in Skye comes out less strikingly, 332 miscellaneous igneous rocks from that island giving a mean of 2·774. In all such calculations it is of course essential that no selection should be exercised, the rocks being taken at random so as fairly to represent *the* variety found within the district.

VII.—ON THE DATES OF THE "PALÉONTOLOGIE FRANÇAISE" OF D'ORBIGNY.

By C. DAVIES SHERBORN.

THE first six volumes of Cretaceous Fossils and the first two volumes of Jurassic Fossils, described in this work, were issued without exact dates, and consequently have caused much confusion in nomenclature.

Information has been obtained from many sources, but that from the *Neues Jahrbuch* seems on the whole more continuously exact.

CRETACEOUS SERIES.

VOL. I.—CEPHALOPODA.

Livr.	1-3,	1840 (N.J., 1840, p. 690).	One sheet to each livr.
	3 [4] - 21,	1841 (N.J., 1841, p. 463).	
	12 [22] - 17 [27],	1841 (N.J., 1842, p. 104).	
	28-32,	1841 (N.J., 1842, p. 235).	
	33-42, pp. 431-662,	1842 (N.J., 1842, p. 455).	

The above is the evidence from the *Neues Jahrbuch* as regards vol. i, but it is evidently so carelessly recorded, markedly so in comparison with the later records, that one must take further evidence. We find that the Geological Society of London received as a present from the author livraisons 1–20, and of these livraisons 9 and 10 were received on January 4, 1841. It will be quite safe, therefore, to regard livrs. 1–10 as belonging to 1840. Now the *Neues Jahrbuch* says that each of the three first parts contained one sheet, and an examination of the volume shows that on this assumption livrs. 1–10 would contain 120 pp. (for the sheets are in 4's and 8's). The *Neues Jahrbuch* is very clear as to the pages contained in livrs. 33–42, and as this is the beginning of their careful record, one may accept the statement as accurate, and we are left with pp. 121–430 for the year 1841. My friend Mr. G. C. Crick, who has examined this volume with me, agrees in determining the date of vol. i, Cretaceous Cephalopoda, as—

pp. 1–120, 1840.
121–430, 1841.
431–662, 1842.
Supplément, 1847 (see below, vol. iii).

The further volumes present no difficulties, and there appears no reason to doubt the record furnished by the *Neues Jahrbuch*.

VOL. II.—GASTEROPODA.

Livr.	43–48	pp.	1–80	1842	...	(N.J., 1842,	p. 843)
	49–60		81–288	1843	...	1843	602
	61–70		289–456	1843	...	1844	60

VOL. III.—PELECYPODA.

Livr.	71–76	pp.	1–96	1844	...	(N.J., 1844,	p. 461)
	77–90		97–288	1844	...	1845	195
	91–102		289–448	1845	...	1845	809
	103–106		449–480	1846	...	1846	479
	107–111		481–520	1846	...	1847	198
	112–116		521–576	1847	...	1847	467
	117–126		577–688 and Supplément to vol. i (Céph.), consisting of livr. 1 and 2, pp. 1–28, pls. ii–ix:	1847	...	(N.J., 1847,	p. 827)

Livr.	127-136	pp. 689-807	1848	...	(N.J., 1848,	p. 560)
VOL. IV.—BRACHIOPODA.		1-16				
	137, 138	17-32	1848	...	1849	81
	139-144	33-104	1849	...	1850	52
	145-152	105-200	1850	...	1850	436
	153-110 [160]	201-328	1850	...	1851	186
	161-164	329-390	1851	...	1851	437
VOL. V.—BRYOZOA.						
Livr.	165, 166	pp. 1-28	1851	...	(N.J., 1851,	p. 580)
	165-168	1-60	1851	...	1851	683
	169-176	61-188	1851	...	1852	61
	177-182	189-265	1852	...	1852	308
	183-188	266-376	1852	...	1852	606
	189-194	377-472	1852	...	1852	945
	195-202	473-600	1853	...	1853	448
	203-208	601-792	1853	...	1853	820
	209-214	793-984	1852 [3]	...	1854	328
	215-218	985-1192	1854	...	1854	432
VOL. VI.—ECHINOIDEA.						
Livr.	209 [219]-226	pp. 1-128	1854	...	(N.J., 1855,	p. 55)
	227-238	129-256	1855	...	1855	683
	239, 240	257-272	1855	...	1856	30
	241-248	273-328	1856	...	1856	677
	249, 250	329-352	1856	...	1857	156
	251-254	353-384	1857	...	1857	318
	255, 256	385-400	1858	...	1858	208
	[?]	401-432	[1858]			
	[?]	433-550	[1860]			

With p. 433 of this volume d'Orbigny's work finished; p.
begins with the following note:—

"Ici se termine le texte imprimé avant la mort de d'Orbig
Ne voulant pas laisser ce volume inachevé, nous avons re
à M. Cotteau, qui à bien voulu se charger de les co-ordonner,
notes manuscrits laissées par l'auteur." (Note de l'éditeur, Ao
1859.)

As new species of Cotteau appear dated 1859 on pp. 495 and 54
pp. 433-550 would appear to date as 1860.

JURASSIC SERIES.

VOL. I.—CEPHALOPODA.						
Livr.	1-5	pp. 1-80	1842	...	(N.J., 1842,	p. 843)
	6-11	81-144	1843	...	1843	602
	12-16	145-192	1843	...	1844	60
	17-19	193-224	1844	...	1844	461
	20-27	225-312	1844	...	1845	195
	28-33	313-368	1845	...	1845	809
	34, 35	369-392	1846	...	1846	479
	36-40	393-432	1846	...	1847	198
	41	(plates only)		...	1847	467
	42-45	433-464	1847	...	1847	827
	46-50	465-496	1818	...	1848	560
	51	497-504	1848	...	1849	81
	52-54	505-520	1849	...	1850	52
	55-58	521-568	1850	...	1850	436
	59-62	569-632	1850	...	1851	186
	63, 64	633-642	1851	...	1851	437
VOL. II.—GASTEROPODA.		1-16				
	65	17-32	1851	...	1851	580

Livr.	65, 66	pp.	33–48	1851	...	(N.J., 1851,	p. 683)
	67–70		49–112	1851	...	1852	61
	71–73		113–152	1852	...	1852	308
	74–76		153–192	1852	...	1852	606
	77–79		193–232	1852	...	1852	945
	80–83		233–288	1853	...	1853	448
	84–86		289–336	1853	...	1853	820
	87–89		337–384	1852 [3]	...	1854	329
	90		385–392	1854	...	1854	432
	91–94		393–424	1854	...	1855	55
	95–100		425–472	1855	...	1855	683
	101		473–480	1855	...	1856	30
	102–105		481–512	1856	...	1856	677
	106		513–520	1856	...	1857	156
	106 [7], 108		521–536	1857	...	1857	318
	[?]		537–end	[1860]			

With p. 536 of this volume D'Orbigny's work finished; precisely he same editorial note is given on p. 537 as has been quoted under ol. vi of the Cretaceous Series, with the exception of the date, hich is "Octobre" instead of "Août." Pages 537 to the end of his volume may therefore be regarded as dated 1860.

Started afresh in 1861, the Committee of Publication for the Paléontologie Française" has followed the excellent practice of rinting an official statement of the dates of publication in each olume. These present notes will, I trust, help to clear away many ifficulties in zoological nomenclature.

NOTICES OF MEMOIRS.

HE DRIFT OR GLACIAL DEPOSITS OF AYRSHIRE. By JOHN SMITH. (Reprinted from the Transactions of the Geological Society of Glasgow, vol. xi, Supplement.) 8vo; pp. 134, with Index. (Glasgow, 1898.)

THAT this is an age of detail is well exemplified in the present memoir. The author records particulars of numerous sections f glacial drift in various parts of Ayrshire, and illustrates his bservations by means of a sketch-map and fifty-two diagrams. The eological Survey in Scotland has been singularly behindhand in ublishing Drift Maps of the country, for, with the exception of ome few six-inch maps where the Glacial gravels and Boulder-clay re represented by a vague kind of stippling, no representations of hese Drifts have as yet been published. This is much to be regretted onsidering the scientific interest as well as the practical value ttached to such maps; and the map now published by Mr. Smith ails to give any adequate idea of the distribution of the Drift. The uthor's observations lead him to conclude that the Ayrshire drifteds comprise about eight divisions. In some sections he finds four oulder-clays, and in all he notes the presence of marine fossils. efore beginning his critical examination he believed that the arious Boulder-clays were 'ground-moraines'; eventually he came o the conclusion that they were deposited in water. That some of is Boulder-clays, such as he describes as pebbly clays, may have een deposited in *water, is not* likely to be questioned. In other cases, where "the Boulder-clays appear occasionally to have b dragged, and in such cases the stones are more intensely stri and the shells scratched, the underlying rock being sometimes up and mixed with the bottom of the clay where the latter is th we should discern more direct evidence of land-ice than the au is willing to admit. He contents himself with the suggestion after the deposition of the beds "they have evidently been subje in many localities, to considerable deformation, chiefly by movement of land-ice." It is hardly necessary to point out the occurrence of Foraminifera is no test of the marine origin of deposits as they now occur, any more than would be the occurr of *Gryphæa arcuata* or *Belemnites abbreviatus*. It is admitted the great bulk of the marine shells occur as fragments, and a few are scratched and polished; and they are recorded by author as occurring in the Ayrshire drift-beds from a dept 35 feet below, to an altitude of 1,061 feet above, sea-level. He not specify the forms found at the different levels and localities, judging from his short general list, four species occur freque and a dozen or more occasionally in the Drifts. There ar indications from the mollusca of the varying depths of water du the time of the supposed marine submergence. Leaving speculative portions of the author's memoir, we cannot doubt the numerous facts recorded by him will be of service to workers on the subject of glacial phenomena.

REVIEWS.

covered with coarse, hard, and stiff hair. He noticed that the small ossicles formed a dense armour in the lower layer of the skin below the hair. He concluded that the skin belonged to a mysterious quadruped which had been described to him some years before by the late Ramon Lista. He therefore named the animal *Neomylodon Listai.*

In January last Dr. F. P. Moreno, Director of the La Plata Museum, arrived in England with a remarkable piece of skin, about half a metre square, which he believed to be the identical specimen of which Dr. Ameghino had obtained some fragments. He exhibited the specimen to the Zoological Society on January 17th, expressing his opinion that it belonged to the extinct *Mylodon.* He further contributed a paper on this interesting discovery to the same Society on February 21st, while Mr. A. Smith Woodward added a detailed description and discussion of the specimen.

It appears that the piece of skin in question was observed by Dr. Moreno early last year hanging in a tree at a farm near Consuelo Cove, Last Hope Inlet, in Southern Patagonia. On making inquiries he found that the specimen had been dug up about two years previously from the floor of a cavern, at a height of, approximately, 200 metres above the sea. Dr. Moreno undertook further excavations at the spot, unfortunately without success; and then he forwarded the specimen by Government transport to the La Plata Museum to await his return.

At the meeting on January 17th much incredulity was expressed as to the antiquity of the specimen claimed for it by Dr. Moreno. In his completed paper, on February 21st, he therefore supported his contention by mentioning that he had found a well-preserved mummified human body in another cavern in the same district, and this certainly belonged to an extinct race of great antiquity, unknown even to the present Tehuelche Indians. Although the skin had a very fresh appearance and had evidently been stripped off the carcass by man, there was thus no difficulty in believing that it really dated back to the time of a fauna which no longer survived.

Mr. Woodward began his description of the specimen by remarking upon its freshness, and pointed to the abundant coating of dried serum on the old cut edges. If Dr. Moreno had not been able to give so circumstantial an account of the discovery, he would, indeed, have unhesitatingly pronounced the skin to belong to a Recent animal killed quite lately. At one corner of the specimen he thought he could recognize the base of the left ear, and thus concluded that the piece of skin probably belonged to the neck. In this case it would be quite large enough for *Mylodon*; but he noticed some slight differences in the minute structure of the dermal ossicles, which might imply that the specimen belonged to a distinct genus. Indeed, the piece of skin was observed to differ from the known dermal armour of *Mylodon*, and that of all other Edentata, in having the ossicles confined to the lower half of the dermis, while the covering of hair was implanted in every part of the upper half. The stiff hair most closely resembled in structure that of the armadillos. Mr. Woodward had searched Lista's writings in vain for a reference to the mysterious quadruped mentioned by that traveller to Ameghino; but as this unknown animal was said to be only about as large as the Indian pangolin, it was evident that ***Neomylodon Listai*** could not be the creature in question.

Since the Zoological Society's meeting on February 21st, Dr. Einar Lönnberg's interesting description of the fragments of skin taken by Dr. Otto Nordenskjöld to Upsala, has reached England. Dr. Nordenskjöld's account of the discovery of the specimen agrees with that of Dr. Moreno; but the Swedish traveller was fortunately on the spot so early as April, 1896, and he was able to make an exploration of the cave soon after the skin was found. He dug up the sheath of a large Edentate claw, which Dr. Lönnberg rightly describes as almost certainly that of a ground-sloth; but he was unable to meet with any other traces of the animal. He only found some little balls of fur, not of ***Neomylodon***, some fragments, probably of the huanaco (***Auchenia***), portions of human bones, and a piece of chipped stone. Dr. Lönnberg's description of the skin agrees closely with that of Mr. Woodward, but the former finds less difference between the microscopical structure of the ossicles in ***Neomylodon*** and ***Mylodon*** than is described by the latter. Dr. Lönnberg also supposes that the cuticle of the hair has been destroyed, while Mr. Woodward regards it as complete. Both agree, however, in considering the animal to have been of very large size; and Dr. Nordenskjöld believes that the largest piece of skin he saw in 1896 was at least 1·5 metres in length.

Whether the piece of skin in question belongs to a recent or to an extinct animal, there are thus considerable difficulties in solving the problems it suggests. If it does belong to ***Mylodon***, as Dr. Moreno maintains, it implies either that this genus survived in Patagonia to a comparatively recent date, or that the circumstances of preservation were unique in the cavern where the specimen was discovered. On the other hand, if it belongs to a distinct and existing genus, as Dr. Ameghino maintains, and as most of the characters of the specimen itself would at first sight suggest, it is indeed strange that so large and remarkable a quadruped should have hitherto escaped detection in a country which has been so frequently visited by scientific explorers.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—February 22, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On Varieties of Serpentine and Associated Rocks in Anglesey." By Professor T. G. Bonney, D.Sc., LL.D., V.P.R.S., F.G.S., and *Miss* C. A. Raisin, D.Sc.

The paper adds certain details to the description published in

1881 by Professor Bonney, and notices some important outcrops near Llyn Dinam and Llyn Penrhyn.

In the serpentine, enstatite frequently, and diallage sometimes, are present; these crystals being occasionally lustre-mottled. The most remarkable variety (which occurs distinctly at seven localities, although generally over a surface of only a few square feet) is that termed 'variolitic serpentine.' On a weathered surface knobs project as upon a variolitic diabase; these, under the microscope, are found to consist mainly of fibrous aggregates, probably actinolitic, sometimes exhibiting a radial structure, but rarely a concentric one. A carbonate is also present in variable amounts. The authors think that probably the original magma of this rock was differentiated, one part representing a pyroxenic constituent and becoming modified by alteration into the spherules; the other (olivine) producing ordinary serpentine.

Intrusive in the serpentine are diallage-rock, enstatite-rock, and rocks composed of both these minerals, all usually containing some serpentine. Various actinolitic rocks, often truly 'actinolitic schists,' probably have been derived through crushing from a diallage-rock (or one allied to it). Other intrusive rocks are the gabbro, which forms large important masses, a dyke of enstatite-gabbro, a porphyrite (?), and some greenstones.

A secondary development of tufted actinolite (compared by the authors with the actinolite in true schists, and with that in the Bastogne rock) is described from at least four localities. It is probably an indirect result of crushing in rocks which, though petrographically different, all originally contained a pyroxenic mineral which has been reconstituted.

Further details are given of the talc-schist and the chlorite-schist in this district, confirming the views that the former rock is a modification of a serpentine, and that the latter was originally intrusive.

The age of these igneous rocks cannot be determined; but they must be earlier than the great earth-movements to which the pressure-structures are due.

2. "Remarks on the Genera *Ectomaria*, Koken, and *Hormotoma*, Salter; with Descriptions of the British Species." By Miss Jane Donald. (Communicated by J. G. Goodchild, Esq., F.G.S.)

This paper deals with some of the genera into which the family of the Murchisoniidæ has been divided, and confines itself to the established genus *Hormotoma*, Salter, and the new genus *Ectomaria*, Koken, which contain some of the oldest known species of elongated Gasteropoda. Both forms are distinguished from the typical *Murchisoniæ* by merely possessing a sinus in the outer lip, instead of having a deep narrow slit with parallel edges; the lines of growth also retreat towards, and advance from, the sinus more obliquely. The author prefers to separate the elongated shells from the shorter Pleurotomariidæ, as Koken does, and to let the former constitute the family Murchisoniidæ.

The genera are described with two new species of *Ectomaria* and two new varieties of *Ectomaria pagoda*, Salt. Six new species of *Hormotoma* are also described, together with the species H. Salteri, Ulrich & Schofield, *H.? gracillima*, Salt., *H. cingulata*, His., and *H. articulata*, Sow. The species of *Ectomaria* are all derived from the Cambrian and Ordovician rocks of Scotland, and the species of *Hormotoma* from various beds, ranging from the Durness Limestone to the Upper Ludlow rocks. An account of the distribution of the genera over Europe and America is also given.

II.—March 8, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "An Analysis of the Genus *Micraster*, as determined by rigid Zonal Collecting, from the Zone of *Rhynchonella Cuvieri* to that of *Micraster cor-anguinum*." By Dr. A. W. Rowe, F.G.S.

The author has endeavoured to show, by means of rigid zonal collecting on a large scale, from the White Chalk of the Southern and South-Eastern coast-sections of England, that the genus *Micraster* is one and the same form gradually evolving from the more simple to the more complex. In doing this, he also contends that the genus may be divided into definite groups, each or several of which are absolutely diagnostic of the various Chalk zones, as defined by Barrois. The conclusions arrived at point to the regular and continuous deposition of the White Chalk, and strikingly confirm the general accuracy of Barrois's zoning.

The paper gives a minute comparison and description of the genus *Micraster* from a general point of view, and from that of a group, and deals particularly with the essential details of the test of the especial groups characteristic of each zone. The author claims that, so far as *Micraster* is concerned, each zone is marked by a definite facies of essential characters of the test, which are purely horizonal, and that all species and varieties, however divergent they may apparently be, occurring at any given horizon, are stamped with the impress of these marked horizonal features.

The author proves that, while in an isolated instance one may be unable to decide the horizon in the White Chalk whence a specimen of *Micraster* was derived, in the ninety-nine other cases the diagnostic features described by him point unerringly to the exact horizon, and thus afford a valuable aid to stratigraphical geology, especially as the essential zonal features of the test are easily made out in the field.

The author discusses the four groups into which the species of *Micraster* in these zones may be placed, and describes in detail the species in these groups.

The paper was illustrated by photographs, micro-photographs, and lantern-slides.

2. "On a Sill and Faulted Inlier in Tideswell Dale (Derbyshire)." By H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

The compact dolerite in the marble quarry in Tideswell Dale has been generally described as a lava; but Sir A. Geikie, in his 'Ancient Volcanoes of Great Britain," suggested the possibility that *it might* be a sill. In the present paper the author endeavours *to prove that* the rock is really a sill. The compact dolerite rests directly on marmorized Carboniferous Limestone in part of the quarry; elsewhere it is separated from it by vesicular 'toadstone' or by a bed of clay which is indurated and rendered columnar for a considerable depth. Above the dolerite comes another vesicular 'toadstone.' Thus the dolerite does not always rest on rocks of the same horizon; while the amount of alteration effected by it is far greater than is usually associated with lava-flows. Taking one bed in the limestone as a datum, the author establishes the following conclusions:—The dolerite does not cut across the beds of limestone; the clay varies in thickness, and is sometimes absent; the clay is rendered columnar and the limestone marmorized to a considerable depth, unless vesicular 'toadstone' of sufficient thickness intervenes, when the 'toadstone' itself is indurated; the base of the compact dolerite is approximately parallel to that of the metamorphosed rock. The dolerite itself is ophitic at its centre, granular above and below, and fine-grained at its margin; it is different in microscopic aspect from the vesicular 'toadstone.' Descriptions of the limestone and marble, the lavas, tuffs, and clay, are also given, and the positions of the faults bounding the inlier are defined.

CORRESPONDENCE.

THE AGE OF THE VALE OF CLWYD.

SIR,—In the article on this subject in your March issue, Mr. Strahan refers to a recent paper of mine on "The Carboniferous Limestone of the Vale of Clwyd,"[1] and to a difference of opinion between us as to the period during which the faulting of the strata occurred. He states that "We differ only on the theoretical question whether the faulting is in part pre-Triassic"; but it seems to me that we also differ as to whether the Trias anywhere overlaps the older rocks. In my paper it is stated that "I failed to find a satisfactory section showing the Trias overlapping any portion of the Carboniferous Limestone or the Purple Sandstone in the Vale of Clwyd," and I might have added, "or the Wenlock Shale."

Mr. Strahan gives several instances where he supposes the Trias to overlap the Limestone, but particularly along the east of the ridge on the west of Llanfair, Dyffryn Clwyd, and refers to "the Trias creeping across the edges of zone after zone of the limestone, until near Ruthin half that formation has been overlapped." In that locality I could not find any evidence of overlap, but that it was the gradually increasing denudation of the Limestone from south to north that caused it to become several hundred feet thinner. Of other examples he gives Bodfari, about which he remarks that "The evidence, however, is more suggestive than conclusive," and he qualifies his references in like manner as to other places. I have searched in vain for some evidence of an overlap by the Trias, but could not find any.

Mr. Strahan, in support of the pre-Triassic faulting, seems to rely on the N.N.W. faults so general along the west of the British Isles, and refers to the Vale of Eden, South Wales, and other distant areas in connection with the Vale of Clwyd. In my paper, however, I relied on the same system of faulting in South-West Lancashire and West Cheshire—about Liverpool and Birkenhead—where there are many such north-and-south faults, dislocating the Trias, and varying from a throw of a few up to 1,000 and even 2,000 feet,[1] equal to any in the Vale of Clwyd and all indisputably of post-Triassic age. This area is only 25 miles from the Vale, so that the conclusion is irresistible that the faults in both areas were produced at the same time. The post-Triassic faults in South-West Lancashire and West Cheshire are as great dislocations as those which traverse the Coal-measures in the country to the east, the only difference being that the Trias has been denuded from off the older strata, after the faulting had been completed.

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[1] Proc. Liverpool Geol. Soc., vol. viii (1897-8), p. 32.

With the exception of the Carboniferous Limestone, there are few really important exposures in the Vale of Clwyd, and most of them afford considerable scope for the use of the imagination, and it is surprising when anyone has a theory to uphold how facts crop up to support it. I have my theory, and appear to see faults where Mr. Strahan does not, while he thinks he can see evidences of the Trias overlapping the Carboniferous Limestone and perhaps the Wenlock Shale where I do not. It seems to me that it is the absence of good sections that is the cause of the difficulty.

I have been indebted to Mr. Strahan for much information, and for the position of exposures which, however, I always examined for myself, while on the other hand I constantly informed him of the progress of my work in many areas in North Wales. No geologist is a more careful observer than Mr. Strahan, and I much regret that he left the Vale of Clwyd before I began to examine it about seven years ago. Still, he has only completed a portion of it, so that when he has finished there may be little difference of opinion between us.

G. H. Morton.

Liverpool, *March* 20, 1899.

THE EASTERN MARGIN OF THE NORTH ATLANTIC BASIN.

Sir,—Will you allow me briefly to reply to the communications from Admiral Sir William Wharton and Mr. Hudleston which appear in the April number of the Geological Magazine, so far as they concern myself.

Presuming from the context that the question to which Admiral Wharton was invited to reply refers to some supposed statement of mine, I have to say that I am not aware of ever having asserted that there are "submarine vertical precipices 7,000 feet or so in height," and, therefore, as far as regards anything I have written I might leave the matter to others. But I can scarcely conceal from myself that the words have been put into my mouth, and I have reason to complain that no reference is given to which I can refer. I have, it is true, called the sub-oceanic 'slope,' along which the Continental platform terminates, 'an escarpment' or 'declivity' of 7,000 feet or more, but that is a very different thing from a 'vertical precipice' of that height. The nearest approach to the above quotation I can find in what I have written is in my paper published in the Transactions of the Victorian Institute for 1896–7, and subsequently in the Geological Magazine, August, 1898, in which I state, and state truly, if the soundings are correct, that the escarpment off the Porcupine Bank of 7,800 feet "is quite precipitous" (p. 354); also that there is "a sheer precipice of 5,000 feet just south of La Rochelle Bank"; but in neither case do I use the word 'vertical,' although, in *some parts* of their descent, the cliffs no doubt *are* vertical. I draw a distinction between a 'precipice' and a 'vertical precipice.' It is very rarely that precipices of a thousand feet and upwards are vertical; but they do not cease to be precipitous at any angle less than (say) about 45° to 50° from the vertical. That some faces of the outer declivity approach these angles, or even exceed them, throughout a portion of their descent from the edge of the British-Continental platform, is fully borne out by the soundings, but it will be observed that this is a very different statement from that which has drawn forth the emphatic reply of the gallant Admiral.

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[1] The boundary fault (2,000 feet) has the Trias only on the downthrow side, but before the country was denuded the Triassic strata were on both sides.

But that there are precipices, in the sense I have explained above, of 6,000 or 7,000 feet in some of the submerged river valleys, such as those (presumably) of the Mondego (lat. 40° 30′ N.) and that which lies off Cave Carveiro (lat. 39° 30′ N.), is clearly shown by the soundings. I cannot expect Admiral Wharton to have recognized them; for even in tracing by a light dotted line the 100-fathom contour on the Admiralty Charts the draughtsman has sometimes lightly skipped across these indentations, which he probably considered of no consequence; still, there they are, when the isobaths are accurately worked out. I cannot, however, but feel obliged to Admiral Wharton for his quotation from the report of Captain Hoskyn when he says, regarding the form of the great declivity: "The intermediate soundings give no evidence [off the coast of Iceland] of a precipice, but a mountain of this height on the land would present an imposing appearance, with perhaps some steep escarpments." This is exactly my own view; and if the reader will examine the sub-oceanic sections given with the map in my original paper in the Transactions of the Victoria Institute, quoted above, he will see that this is so.

Referring now to Mr. Hudleston's important contribution in the March and April numbers of the Geological Magazine, I have nothing to complain of the manner in which he has dealt with my own views; and I am glad that, once and for all, he has given his powerful aid in favour of the view that the British-Continental shelf was at a former time a land surface, and that "so long as Professor Hull confines himself to tracing the old river-courses cut in the continental shelf he is pretty safe" (p. 153). It then only remains to be determined to what depth below the general level of the platform the channels may be carried down;

and without drawing in the least on that "scientific imagination" with which my distinguished friend is kind enough to credit me, and relying only on the use of my reasoning faculty, I maintain that they must be carried down to the lowest levels shown by the soundings, since rivers only flow at the bottom of their valleys! And, in this connection, let me ask Mr. Hudleston with reference to his plan of the Gulf of Gascony and his isobathic contours of 100 fathoms and 1,000 fathoms of the Fosse de Cap Breton (p. 151), why has he left the latter in so incomplete a state? The 1,000-fathom contour is broken in two just above the point where the narrow channel of 1,500 fathoms opens out on the abyssal floor, as will be seen by reference to the map itself. Surely with so many soundings there can have been no great difficulty in carrying the 1,000-fathom line eastwards to the point of crossing, which would indicate the form of this remarkable sub-oceanic ravine; and if contours of intermediate depths (say 750, 500, and 250 fathoms) had been traced, they would have thrown additional light on its form and character. As it stands, Mr. Hudleston's map is unintelligible, and reminds me of that of M. Elisée Reclus, who leaves the mystery of the Fosse de Cap Breton unsolved.

EDWARD HULL.

April 7, 1899.

THE ASSOCIATION OF *SCHLŒNBACHIA INFLATA* WITH *HOPLITES INTERRUPTUS.*

SIR,—In discussing "The Base of the Gault in Eastern England" thicker in that district than has hitherto been supposed. It must be remembered that the fossils are phosphatic, and the section exposed when I was there in 1884 showed that they lay in a seam of phosphatic nodules; hence some of them may have been derived from a lower horizon, but the occurrence of *S. rostrata* and *S. varicosa* within 20 feet of the base of the Gault remains to be explained.

A. J. JUKES-BROWNE.

TORQUAY, *April* 10, 1899.

OBITUARY.

JAMES DIGUES LA TOUCHE, B.A.

BORN APRIL 7, 1824. DIED FEBRUARY 24, 1899.

SOME five and forty years ago the Rev. James Digues La Touche of Stokesay, with Humphrey Salwey and Robert Lightbody of Ludlow, formed a trio of ardent students of the geology of South Shropshire. Surviving his fellow-workers for more than twenty years, the late Vicar of Stokesay is the best known to the present generation of geologists, and moreover, while all were equally willing to impart to others their intimate knowledge of the geology of their neighbourhood, he did not share his friends' reluctance to commit to writing the information which they acquired.

In his earlier geological papers he attacked two problems of considerable difficulty, one being the changes which sedimentary rocks undergo after their deposition and consolidation, and the other the amount of sediment brought down by rivers as a measure of the extent of denudation of the land. While we may not fully accept his original views on the "Mode of Formation of Limestone Bands" (Geologist, 1863), it is probable that "Nodules in the Limestone of Wenlock Edge" (Brit. Assoc. Rep., 1865) and "Spheroidal Structure in Silurian Rocks" (Journ. Geol. Soc. Ireland, 1871) have been formed in the way which he suggests, so that his first paper merely carries his theory a little too far. The difficulties encountered in the study of the "Alluvial Deposits of Rivers" (Trans. Woolhope Field Club, 1868) and the "Measurement of River-sediments" (GEOL. MAG., 1868) are of quite another kind, being chiefly manipulative, and it seems a pity that the very careful and well thought-out experiments which he made to form an "Estimate of the Quantity of Sedimentary Deposit in the Onny" (Brit. Assoc. Rep., 1869) should have terminated with his "Report on the Sedimentary Deposits of the River Onny" presented to the British Association in 1870, and published as one of the "Reports on the State of Science" in the volume for that year. His papers in the Transactions of the Woolhope Field Club on the "Geology of the District around the Titterstone Clee Hill" (1868) and on the "Geology of the Longmynd Hills" (1870) should be read by all who wish to study these interesting districts.

His principal work, however, is "A Handbook of the Geology of Shropshire," published in 1884 (4to, London and Shrewsbury).

Commencing with a succinct but not very full account of the geological formations, from Pre-Cambrian to Lias, which are represented in the county of Salop, a few pages are very usefully devoted to the description of a number of routes by which these formations may be seen and conveniently studied, the best localities for fossils being pointed out. The remainder and much the greater part of the work is palæontological, consisting of descriptions of fossils, first of the genera and then of the species, which are depicted on 22 plates. A few new species are described and figured.

In July, 1872, he conducted, with Prof. Morris and Mr. Lightbody, an excursion of the Geologists' Association to the neighbourhood of Ludlow and the Longmynds, which was highly successful.

Geology was not his only scientific study; it was but one of many. In 1875 he contributed a paper to the Meteorological Society (a result of a visit to Natal, where he went in 1874 to assist Bishop Colenso); he kept a rain-gauge and other meteorological instruments; and from the year 1876 the rainfall at Stokesay Vicarage has appeared annually in Symons' "British Rainfall." Through his astronomical work he became acquainted with Sir William Herschel, grandson of Herschel I. He studied microscopical petrology, making rock-sections with a machine of his own designing and examining them under the microscope until his eyesight became affected, when he turned his attention to the practical study of electricity, constructing the necessary apparatus himself. In Natural History his favourite studies were entomology and botany; he was expert in dissecting insects, and he made a complete collection of the plants of his neighbourhood. In his parish is the only British locality for *Astrantia major*, and he was proud to show this plant growing to those whom he could trust to look and not to take, but careful not to do so to the mere collector. It may be that his taste for botany and love of flowers were acquired from his intimate friend Sir Joseph Hooker. He had considerable archæological knowledge, as his "Guide to Stokesay Castle" attests, and at the time of his death he had just completed a history of his parish intended for publication.

With these diversified studies Mr. La Touche was also assiduous in parochial work. His ancestors on both sides being of Huguenot extraction, he appears to have inherited an intense desire, with the needful ability, to help those around him to acquire useful knowledge and to become expert artisans. He not only taught daily in his parish schools such subjects as Latin, French, mathematics, land-surveying, and shorthand, but he also had a room built which he fitted up with carpenter's bench, lathe, and a chemical laboratory, where he gave practical instruction in various useful arts, including bookbinding. His fame as a tutor was worldwide, and amongst his private pupils were sons of Bishop Colenso, of Professor Max Müller, and of Sir Joseph Hooker, and two nephews of Sir Charles Lyell.

As Vicar of Stokesay for the long period of 44 years, he had endeared himself to his parishioners, who will miss his commanding but genial presence, his deep-toned but pleasant and cheery voice. He leaves a widow, three sons, and two daughters. His eldest son, who is in the Church, succeeds his father as Vicar of Stokesay; one is on the staff of the Geological Survey of India; and the other is a Civil Engineer in the Public Works Department of the Madras Presidency. J. H.

OTHNIEL CHARLES MARSH, LL.D. (YALE), PH.D. (HEIDELBERG).

BORN OCTOBER 29, 1831. DIED MARCH 18, 1899.

(WITH A PORTRAIT.)

SCIENCE of late has become so cosmopolitan in its interests that the loss of any one of its leading members is felt and mourned in distant lands as keenly as in the University in which he may have made his home.

A while since we had to regret the loss of Professor Dames of Berlin; yesterday we deplored that of Professor Nicholson of Aberdeen; to-day we mourn the loss of our dear American cousin, Professor O. C. Marsh of Yale. Such ties of sympathy and personal regard tend to knit more closely together our geological friends everywhere, and we join hands far and near in times of joy and sorrow.

O. C. Marsh was born at Lockport, New York, October 29, 1831, and graduated at Yale in 1860. Of his early years we have no details, but it may be inferred that it was due to the interest of his uncle, Mr. George Peabody, that after his schooldays had long ended he entered Yale College, where he graduated in 1860 at the age of 29. After travelling in Canada and Nova Scotia, where he discovered remains of a new Enaliosaurian (*Eosaurus Acadianus*) in the Coal-formation of Nova Scotia, he came to Europe and spent three years in the Universities of Berlin, Heidelberg, and Breslau, under Beyrich, Ehrenberg, Roemer, and other famous German Professors.

He visited London in 1864, and whilst diligently studying in the British Museum he became acquainted with the writer, and from that time a warm friendship was commenced, which lasted to the end. A letter arrived on the morning of the 20th March, addressed in Marsh's well-known handwriting, and also a telegram, the former full of life and pleasant hopes and promises, the latter the messenger of death: "Professor Marsh died yesterday, illness short, Beecher." Reverting again to 1864: we had just before (1862) secured the famous collection of Dr. Haberlein from the lithographic-stone quarries of Eichstatt, in Bavaria, which, among other treasures, contained the famous *Archæopteryx*. Marsh at that time devoted himself diligently to the investigation of the fossil Annelides, and discovered on one specimen the well-preserved jaws of *Helminthodes antiquus*, which he carefully worked out with his own hands and afterwards described and figured.

Returning to America in 1866, he joined Professor Sir William Thomson (now Lord Kelvin) when engaged in the delicate task of picking up and splicing the first Anglo-American cable in mid-Atlantic. The same year he was offered the Chair of Palæontology at Yale University, the Professorship being instituted for him, and there he remained until the close of his career. Within two years after his appointment Marsh ceased to write miscellaneous papers, and devoted all his time, energies, and resources to the pursuit of Vertebrate Palæontology.

Aided by the liberality of his uncle, Mr. George Peabody, the founder of the Peabody Museum of the Yale University, Marsh commenced a series of expeditions for palæontological purposes to the Rocky Mountain region and the Far West. One of the earliest of these was in 1870, and lasted more than five months. It extended into Kansas, Nebraska, and Utah. The fossils obtained were chiefly from the "Loup River" Pliocene and the "Mauvaises Terres" or Miocene, both deposits having been accumulated beneath the waters of enormous fresh-water lakes, whose banks were tenanted by many of the peculiar Pachyderms of the Paris Basin. Many species of fossil horses (one of them allied to *Hipparion*), of Rhinoceroses, of *Titanotherium*, an *Elotherium*, camels, and carnivores were secured. These old lake-deposits of Miocene age abound in remains of crocodiles, serpents, turtles, and fishes. Numerous Mosasaurian remains also were obtained in Kansas. Another expedition followed in 1874 to the south of the Uintah Mountains, and was equally successful.

From the date of Professor Marsh's establishment at Yale University, a long succession of scientific papers appeared, mostly in Silliman's American Journal and in the GEOLOGICAL MAGAZINE.

Of his earlier papers may be mentioned the following:—On the discovery of a diminutive species of fossil horse (*Equus parvulus*); Reptilian remains from Brazil; Mosasauroid reptiles from New Jersey; a gigantic fossil serpent (*Dinophis grandis*) from New Jersey; fossil birds from the Cretaceous and Tertiary; a fossil Gavial from New Jersey; a gigantic species of Pterodactyle; new Tertiary mammals and birds; on *Hesperornis regalis*, a toothed bird; notes on *Tinoceras*; fossil quadrumana and carnivora from Wyoming; a new species of *Ichthyornis*; fossil mammals of the order Dinocerata; on the genus *Tinoceras*, etc.; on the structure of the Brontotheriidæ; new equine mammals; on the small size of the brain in Tertiary mammals; on the Tillodontia; on the genus *Coryphodon*; on the Pterosauria; on the Stegosauria, a new order of extinct Reptilia; on the Sauranodonta and principal characters of American Jurassic Dinosaurs; on Dinosaurian reptiles from the Jurassic formation; new Jurassic mammals.

Professor Marsh's first great work appeared in 1880 on the *Odontornithes*, a monograph on the extinct toothed birds of North America (4to, pp. xv + 201, with 34 plates and 40 woodcuts). Certainly, as a scientific publication, it surpasses any which have already appeared devoted to palæontology.

In the same geological horizon with the *Odontornithes*, Professor Marsh discovered and described *the first Pterodactyles*, or flying-lizards of America. These are of enormous size, having a spread of wings of nearly 25 feet, and were specially remarkable for having no teeth, hence resembling our modern birds.

The bird-like Fossil Footprints of the Triassic sandstones from the Connecticut Valley always interested Marsh, and he keenly and critically studied them; as, although no bones had been found near them, they had been regarded as undoubted footprints of birds, because it was supposed that birds alone could make such series of bipedal, three-toed tracks, and leave no impression of a tail. Marsh was able in later years to show that these bird-like tracks were most probably made by a small bipedal reptile named *Anchisaurus*, an early Triassic dinosaur.

In 1884 appeared the second of Marsh's great works, a Monograph on the extinct Dinocerata, a gigantic order of Ungulate mammals (Washington, 4to, pp. xviii and 237, with 56 plates and 200 woodcuts). These huge beasts, which nearly equalled the elephant in size, roamed in great numbers about the borders of the ancient Eocene lake-basin in Wyoming, where so many of them were afterwards entombed, The drainage of this lake by the Green River, its elevation from six to eight thousand feet, and subsequent erosion by the Colorado, has left exposed by slow denudation the great ‘*mauvaises terres*,” or “bad lands,” carved into peaks, cliffs, and columns of the most fantastic and varied shapes and colours, and has exposed the remains of the many extinct animals and the bones of the great Dinocerata for the attention of the explorer. More than 200 individuals of the Dinocerata have been brought together in Yale College Museum alone.

A *papier-maché* model, taken from the actual bones of the complete skeleton of *Tinoceras ingens*, has been presented by Professor Marsh to the Geological Department of the British Museum (Natural History), London, and serves as an interesting memorial of his work.

Professor Marsh's third Monograph is on the Dinosaurs of North America, and appeared in 1896 (imperial 8vo, pp. 110, with 84 plates). No fewer than fourteen papers, richly illustrated, had already appeared on this subject in the GEOLOGICAL MAGAZINE from 1882 to 1896, so that this Monograph could not be expected to add much to the knowledge already derived from the author's numerous separate memoirs. But all Marsh's work on the Dinosauria is here brought into one focus. Many fine plates were held back by him, as well as many details, for a future *édition de luxe*, which, alas! he never lived to produce, but which will doubtless be published at an early date by the University of Yale, provision having been made for that purpose by Professor Marsh in his will.

An excellent summary of Marsh's observations on Dinosaurs will be found in the GEOLOGICAL MAGAZINE, 1896 (pp. 388-400), with twelve admirable restorations of the leading forms. (See also GEOL. MAG., 1897, pp. 38-44.)

Marsh's toothed birds and toothless Pterodactyles may seem to be two of the most remarkable of his numerous discoveries; but his Monograph on the Dinocerata is in itself a grand and classical piece of work, sufficient alone to merit the highest distinction.

Yet if we turn to his long researches upon the Dinosauria, one would feel certainly disposed to give to these the first place of importance in his lifework. Such wonderful forms of ter reptiles as he has discovered, e.g., *Brontosaurus*, *Stego Triceratops*, *Claosaurus*, *Anchisaurus*, *Ceratosaurus*, *Diplodoc* many others, either by their size or peculiar characters produced a more powerful impression on the public min almost any of the other discoveries of modern science.

From 1868 to 1890 scientific expeditions were organised to e and collect fossils in the Rocky Mountain districts, resulting bringing to Yale of more than a thousand species of verte more than 400 of which have been described by Professor He is said to have crossed the Rocky Mountains thirty times o expeditions, and, although he may not have crossed the A quite so often, he was a very frequent visitor to England a Continent, and his relations with men of science here were friendliest kind: witness the award to him of the first Bigsby in 1877 by the Council of the Geological Society, who also him a Foreign Member in 1898.

Of the struggles for priority and other personal sci squabbles which embittered some years of his life we ne now speak; over the silent grave we may only remembe gratitude the vast services to science which Marsh lived to pe

By his will he leaves his entire estate to Yale University, w exception of 10,000 dollars to the National Academy of Scien promote original scientific research. Even his home and res are left to the Yale University, to be used as a Botanic Gard Laboratory. He is estimated to have expended 250,000 doll collecting the fossils which he gave to the Yale Museum ago. His estate will probably realize 100,000 dollars. (It be also mentioned that during the thirty-three years in Professor Marsh held the Chair of Palæontology in Ya received no salary for his services.)

A sum of 30,000 dollars is left to the Trustees of the P Museum, to pay for the preparation and publishing of the res his explorations. In this case we may *reverse* the *ver* Shakespeare and say,

"The *good* men do lives after them."

I cannot help quoting a few words from Marsh's last letter Yale, March 10th, 1899:—"I did not intend to distribute m these [casts] until after my monographs were publishe considering what confusion there seems to be in your coun the subject [of the Dinosauria], good casts of the charac American specimens might help on the missionary work of sc instruction, and thus aid in bringing still nearer together o countries."

It seems sad that he, who was with us at the August m of the International Zoological Congress at Cambridge, a subsequent meeting of the British Association at Bris *September*, reading and discussing papers there, should now *passed* over to the great majority and that we should see h *no more.*

H.

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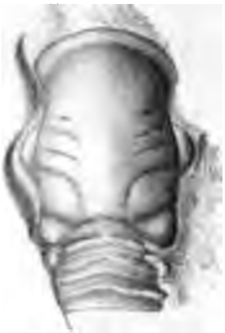

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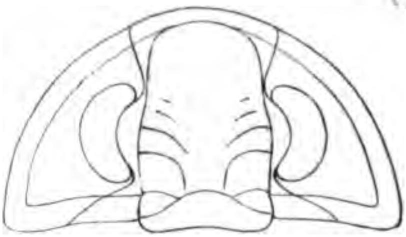

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THE
OLOGICAL MAGAZINE.

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ORIGINAL ARTICLES.

WOODWARDIAN MUSEUM NOTES: A NEW CARBONIFEROUS TRILOBITE.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE X.)

ONGST the fossils collected from the Pendleside Limestone
of Butterhaw Knoll, Cracoe, Yorkshire, in which *Cyphaspis*
ina (Coignou)[1] was discovered a few years ago, there are
e Woodwardian Museum a few specimens of a species of
psia, which were found in 1889 by Professor Hughes' same
ical party. My attention has been recently directed to
and it has become evident, after a careful examination, that
lo not belong to any of the hitherto described species of this
. The characters of this new species, to which the name
psia cracoensis is given, are as follows:—

d-shield nearly semicircular; glabella regularly and gently
x, slightly elevated above the cheeks, cylindrical but narrowing
e in front of the eye-lobe. Anterior end of glabella rounded,
aching front margin of head-shield, but separated from it by
row rounded border ornamented with a few concentric lines.
lla marked off from neck-ring by a strong undulating neck-
consisting of a central portion arched forwards and oblique
l portions bounding the basal lobes of the glabella.

al lobes of the glabella subquadrate in form, distinctly defined
rrows curving back towards the neck-furrow, before reaching
they become weaker. In front of the furrows defining
orly the basal lobes the glabella is marked by three pairs of
s directed obliquely backwards. The posterior pair is the
est and longest; the middle pair does not join the axal
; and the anterior pair, though invariably present, is very
and in some specimens is represented merely by a pair of
pits.

k-ring broad and band-like, median portion averaging one-
the length of glabella and wider than first thoracic segment.
ior part of lateral portion of neck-ring swollen on each side
d basal lobe to form a small low, elongated, triangular nodule,

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[1] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 422.

with shortest side on axal furrow. Small median tubercle also present on neck-ring.

Facial suture cuts anterior border of head-shield almost at a right angle; from this point it curves backward and inward to the glabella, bending again outwards between the first and second glabella-furrows and defining a large, long, crescentic eye-lobe, at the base of which it turns sharply outwards and runs in an oblique direction to meet the posterior border of the head-shield at a very acute angle.

Eye-lobe extends from second furrow of glabella nearly to neck-furrow.

Free-cheek smooth, triangular, surrounded by raised rounded border ornamented with four or five raised concentric lines on upper surface. Genal angle obtuse, not produced into a spine.

Eye large, reniform, prominent, marked off from surface of free-cheek by encircling, broad, shallow groove. Surface finely facetted as in *Phill. gemmulifera.*

Thorax incompletely known. In one partly enrolled specimen seven segments of the axis are preserved which are attached to a head-shield. These segments are smooth and devoid of tubercles. The axis is gently convex, and very gradually diminishes in width towards the pygidium. The pleuræ in this specimen are unfortunately broken off, but were apparently about equal in breadth to the axis.

Pygidium semicircular, gently arched, edge smooth, slightly bevelled, without any marginal rim or grooved area. Axis prominent, rounded, rather more than one-third the width of pygidium, composed of twelve rings, each bearing an almost obsolete low median tubercle (scarcely visible on the posterior rings), with a lateral, stronger tubercle on each side, separated from the median one by a distinct, small, oval, striated patch, visible only in the cast. Axis extends a little over three-fourths the length of the pygidium, gradually tapering to its posterior end, which is obtusely pointed. A faint ridge slopes down with diminishing strength from the end of the axis to the margin of the pygidium.

Pleural portions of pygidium, forming area gently arched downwards from axis, marked on each side by 8–10 ribs, of which only the first three or four are distinct, the posterior ones being very faint and almost obsolete. The first furrow is strong and reaches the lateral margin of the pygidium; the second becomes weak before reaching the margin; the third is still weaker and shorter; the fourth is generally distinguishable in the cast, but those behind it are scarcely visible. The ribs are each marked with a central longitudinal groove, and each rib bifurcates at the weak fulcrum, which is situated about half-way along their length and is only perceptible in the first two or three ribs. These three first ribs reach the margin with distinctly bifurcated ends, but decrease in strength beyond the fulcrum. The posterior ribs, though much weaker along their whole length, are, nevertheless, traceable to the *pygidial* margin.

The actual surface of the pygidium is not preserved in its entirety in any of our specimens, but from isolated fragments of the shell attached to the casts the above features can be made out. A fine punctation is also noticeable on the surface with a hand-lens. The under surface of the pygidium is furnished with a broad infolded marginal portion ornamented with concentric striæ.

Hypostome elongate, obtusely pointed posteriorly; central portion convex, swollen, with subparallel sides; anterior portion most elevated, ornamented with several longitudinal lines, and provided with a narrow border marked off by a faint groove. Alæ subquadrate rather than triangular in shape, marked with irregular wrinkles, not separated from central portion of hypostome by furrow. Rounded narrow border surrounding posterior part of central portion behind alæ, but marked off from it by distinct groove. Lateral angles obtuse.

MEASUREMENTS OF SIX SPECIMENS OF HEAD-SHIELDS AND PYGIDIA.

	mm.	mm.	mm.
Length of head-shield ...	11·5	11·0	9·0
Length of glabella	9·0	8·0	7·0
Width of glabella at base ...	7·0	6·5	6·0
Length of pygidium ...	11·0	10·0	8·0
Width of pygidium ...	16·0	14·5	12·0
Length of axis	9·0	8·0	7·0
Width of axis at front end ...	6·0	5·25	5·0

Affinities.—This new species, *Phill. cracoensis*, has wide affinities, but does not appear to be closely allied to any of the British species. The want of genal spines to the free cheeks recalls *Phill. derbiensis* (Martin), but in almost every other detail the head-shield is different, and the pygidium, moreover, bears no resemblance.

With *Phill. Colei* (McCoy) it agrees in the general shape and marginal characters of the pygidium, in possessing the same number of segments on the pygidial axis, and in the faintness of the pleuræ on the lateral portions. But it differs in the shape and ornamentation of the axis, and in the more strongly marked fulcrum and the bifurcation of the ribs. The head-shield is completely different, except in the relative size of the eyes; and the hypostome is narrower, has larger alæ, and a more strongly developed posterior border.

The general shape of the glabella and course of the facial suture are somewhat similar in *Phill. gemmulifera* (Phillips), but in all other respects the differences are marked. The three pairs of furrows on the glabella, in addition to the one marking off the basal lobe, recall *Phill. truncatula* (Phillips). But the pygidium shows little similarity.

From *Phill. Eichwaldi* (Fischer) our species is in most respects so completely different as to make any comparison needless. But a hypostome doubtfully referred to *Phill. Eichwaldi* by Dr. Woodward[1] is not unlike that of *Phill. cracoensis*, except in its less elongate form, less regularly convex axis, and triangular alæ.

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[1] Mon. Brit. Carb. Trilob., p. 22, pl. iv, fig. 4.

The fewer glabellar furrows of ***Phill. laticaudata*** (Woodw.), the ornamentation of the axis of the pygidium, and the non-bifurcation of its pleuræ, compel us to regard this species as distinct, though it agrees in the shape of the pygidium and number of axial segments.

Phill. scabra (Woodw.) shows several points of resemblance, i.e., the non-elongation of the genal angles into spines, the striated border of the free cheeks, and the large eyes; but the shape and furrows of the glabella and the pygidium are quite different.

Phill. quadrilimba (Phillips) and ***Phill. carinata*** (Salter) are completely unlike ***Phill. cracoensis*** so far as they are known.

In *Phill. Leei* (Woodw.) the pleuræ of the pygidium are grooved, the neck-ring of the head is widest in the centre, the margin of the head is ornamented with parallel lines; but the eyes, the fixed cheeks, the glabellar furrows, and number of rings in the axis of the pygidium are different. ***Phill. Cliffordi*** (Woodw.), of which the head-shield resembles that of ***Phill. Leei***, has bifurcated pleuræ in the pygidium, but there are thirteen rings on the axis, and these are unornamented. ***Phill. minor*** (Woodw.) has also bifurcated pleuræ on the pygidium, but fourteen unornamented segments on the axis and an entirely different head-shield. ***Phill. articulosa*** (Woodw.) shows no important points of resemblance, nor does ***Phill. Van der Grachti*** (Woodw.).[1] ***Phill. Polleni*** (Woodw.),[2] though agreeing with ***Phill. cracoensis*** in the shape of the pygidium, the faint pleuræ, and course of the facial suture, is in other respects unlike it, but Dr. Woodward considers it allied to ***Phill. Colei***.

The pygidia on which the species *Griffithides? carringtonensis* species of this genus, which have been described above, show that it is a generalized form, and suggest the idea that *Phillipsia* is separable as a distinct genus from *Proetus* more for stratigraphical than morphological reasons.

EXPLANATION OF PLATE X.

Fig. 1.	*Phillipsia cracoensis*, n.sp.	Central portion of head-shield. × 3.
,, 2.	,, ,, ,,	Central portion of another head-shield. × 3.
,, 3.	,, ,, ,,	Pygidium. × 3.
,, 4.	,, ,, ,,	Another pygidium. × 3.
,, 5.	,, ,, ,,	Free cheek. × 3.
,, 6.	,, ,, ,,	Hypostome. × 3.
,, 7.	,, ,, ,,	Outline restoration of head-shield.

II.—On *Archanodon Jukesi* (Forbes MS.), Baily, sp., from the Old Red Sandstone of Monmouthshire.

By R. Bullen Newton, F.G.S.

Introduction.

THROUGH the kind intervention of Professor H. G. Seeley, F.R.S., some few years since, Mr. Percy Hawkins was induced to present to the Geological Department of the British Museum a slab of Old Red Sandstone from Llanvaches, nearly midway between Caerleon and Chepstow, Monmouthshire, containing some excellent impressions of *Archanodon Jukesi.*

Originally found in Ireland, and since reported from Northumberland, the present notice of the shell forms a second record of its occurrence in Britain. So far as our knowledge extends, it remains the most ancient lacustrine or fluviatile bivalve mollusc yet known in the British Islands, and on that account, coupled with its great rarity, it is hoped that the following account, dealing with its discovery in Western England, may lend an additional interest to the species. Before entering upon this, however, it may be of advantage to submit a brief summary of the literature relating to this organism.

Bibliographical Review of Archanodon Jukesi.

The first reference to this mollusc was made by Edward Forbes[1] in 1853 in a provisional list of fossils characterizing the 'Yellow Sandstone' at the hill of Knocktopher, co. Kilkenny, Ireland, which included plants (*Cyclopteris Hibernicus*, *Lepidodendron*, and *Stigmaria*), fish (*Holoptychius*), Crustacea (*Pterygotus*), and a 'large bivalve shell,' to which was given the name of *Anodon Jukesi.* These forms of life were recognized as indicative "of fresh or at least brackish water conditions at the period of the deposition of the beds."

In 1857 J. B. Jukes and J. W. Salter[2] referred to the occurrence of *Anodon Jukesi* in the Yellow Sandstone of Kiltorcan Hill, near

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[1] Edward Forbes, "On the Fossils of the Yellow Sandstone of the South of Ireland": 22nd Rep. British Assoc. for 1852, published 1853, p. 43.

[2] J. B. Jukes and J. W. Salter, "Notes on the Classification of the Devonian and Carboniferous Rocks of the South of Ireland": Journ. Geol. Soc. Dublin, vol. vii (1857), p. 63.

Thomastown, and at Tivoli Villa, near Cork, in association with plant remains, regarding the beds as belonging to the Upper Old Red Sandstone.

Later on in the same year Jukes[1] appears to have altered his opinion as to the age of the Yellow Sandstone Series of the South of Ireland, and considered them as of Lower Carboniferous age, a view which was supported by Sir Richard Griffith[2] in the following year (1858).

As a list name, W. H. Baily[3] in 1859 referred to this shell under the name of *Anodonta Jukesi*, recognizing its formation as Upper Devonian or Lower Carboniferous, although in the following year (1860) he[4] acknowledged the deposit as of Upper Old Red Sandstone age.

In 1861 Baily[5] invested the fossil with a greater scientific importance by publishing figures and a description. His account is as follows:—"The large bivalve shell, *Anodonta Jukesi*, Forbes, of which figures are given (reduced to half natural size), is rather abundant at Kiltorcan Hill, occurring with the plants before mentioned [*Adiantites* (*Cyclopteris*) *Hibernicus*, *Sphenopteris Hookeri*, *Cyclostigma*, *Lepidostrobus* ?]; no other mollusc having hitherto been found in those beds. It is clearly allied to the fresh-water mussels of the present day, being referred to an existing genus which is remarkable for the thinness of its shell and the absence of hinge teeth. Fig. 3*a* exhibits the exterior of this elongated shell, with its well-marked lines of growth, characters common to the existing fresh-water Unios and river mussels; 3*b* is from a cast of the interior of the left valve of a very large specimen; it shows the impression or cicatrice of the adductor muscle and the straight toothless hinge-line."

Another locality for the mollusc was noted by Baily[6] during 1864, viz. Gokane Point, Toehead Bay, co. Cork, where it was found associated with *Adiantites Hibernicus*; and in 1866 J. B. Jukes[7] recorded its discovery by Mr. Doran in the Old Red Sandstone of near Clonmel (Waterford).

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[1] J. B. Jukes: "The Student's Manual of Geology," 1857, p. 441.

[2] Sir R. Griffith, "On the Remains of Fossil Plants discovered in the Yellow Sandstone Strata, situate at the base of the Carboniferous Limestone Series of Ireland, in connection with a Communication on that subject from M. Adolphe Brongniart": Journ. Royal Dublin Soc., vol. i (1858), p. 313.

[3] W. H. Baily, "On the Fructification of *Cyclopteris Hibernica* (Forbes) from the Upper Devonian or Lower Carboniferous Strata at Kiltorkan Hill, Co. Kilkenny": 28th Rep. British Assoc. for 1858, published 1859, p. 75.

[4] W. H. Baily, "On *Sphenopteris Hookeri*, a new Fossil Fern from the Upper Old Red Sandstone Formation at Kiltorcan Hill, in the County of Kilkenny, with some Observations upon the Fish Remains and other Associated Fossils from the same locality": 29th Rep. British Assoc. for 1859, published 1860, p. 98.

[5] W. H. Baily: "Explanations to Sheets 147 and 157 of the Maps of the Geological Survey of Ireland," 1861, p. 16, fig. 3.

[6] W. H. Baily, "Explanations to Sheets 187, 195, and 196 of the Maps of the Geological Survey of Ireland," 1864, p. 23; "Explanations to Sheets 192 and 199 of the Maps of the Geological Survey of Ireland," 1864, pp. 15, 17, 23.

[7] J. B. Jukes, "On the Carboniferous Slate (or Devonian Rocks) and the Old Red Sandstone of South Ireland and North Devon": Quart. Journ. Geol. Soc., vol. xxii (1866), p. 320.

As bearing upon the geological age of the fossil, reference may be made to Oswald Heer's[1] researches of 1872. This author regarded the Yellow Sandstone beds of Kiltorcan as of Lower Carboniferous age, after a comparison of its flora with that found in the Mountain Limestone of Bear Island. Further allusions to the species were published by Baily[2] in 1875, and another figure (copied from original illustration) was issued, but no new facts were made known.

Considerable interest was added to the subject by Richard Howse[3] in 1878, when he announced the discovery of this shell in the sandstone rocks of North Northumberland associated with *Ulodendron ornatissimum* and stems of *Calamites*. Its horizon he recognized as an upper member of the Tuedian group of the late Mr. George Tate, which he considered closely identical with the lower part of the Calciferous Sandstones of Scotland; further stating that "the supposed Upper Old Red Beds of Kilkenny will also no doubt be eventually and correctly correlated with these." In this account Mr. Howse established the new generic name of *Archanodon* for *Anodon* or *Anodonta*, as the shell had hitherto been called.

During the same year (1878) G. H. Kinahan[4] tabulated the Kiltorcan rocks containing *Anodonta Jukesi*, etc., as Lower Carboniferous. Mr. Howse[5] in 1880, as a correction of a priority dispute, again referred to the Northumberland form of *Archanodon Jukesi*, and mentioned a more precise locality for it than in his original account, viz., near Chillingham.

Dealing with the question of horizon, Professor Hull's[6] remarks of 1880 on the Kiltorcan rocks may be of interest to quote: "The occurrence of fish remains in the Kiltorcan Beds belonging to recognized Old Red Sandstone forms of Scotland and elsewhere, none of which ascend to the Carboniferous Series of other districts, places the relations of these beds to the Old Red Sandstone beyond question. The occurrence of *Anodonta Jukesi*, *Palæopteris*, fish, etc., all point to the fact that lacustrine conditions prevailed over this area of Southern Ireland during the deposition of these beds."

In the succeeding year Professor W. Boyd Dawkins[7] contributed

[1] Oswald Heer, "On the Carboniferous Flora of Bear Island (lat. 74° 30′ N.); and on *Cyclostigma*, *Lepidodendron*, and *Knorria* from Kiltorcan": Quart. Journ. Geol. Soc., vol. xxviii (1872), pp. 161–173, pl. iv.

[2] W. H. Baily, "On Fossils from the Upper Old Red Sandstone of Kiltorcan Hill in the County of Kilkenny": Proc. Royal Irish Academy, ser. II, vol. ii (1875), pp. 45–48. "Figures of Characteristic British Fossils: Palæozoic," 1875, p. 93, pl. xxxi, fig. 5.

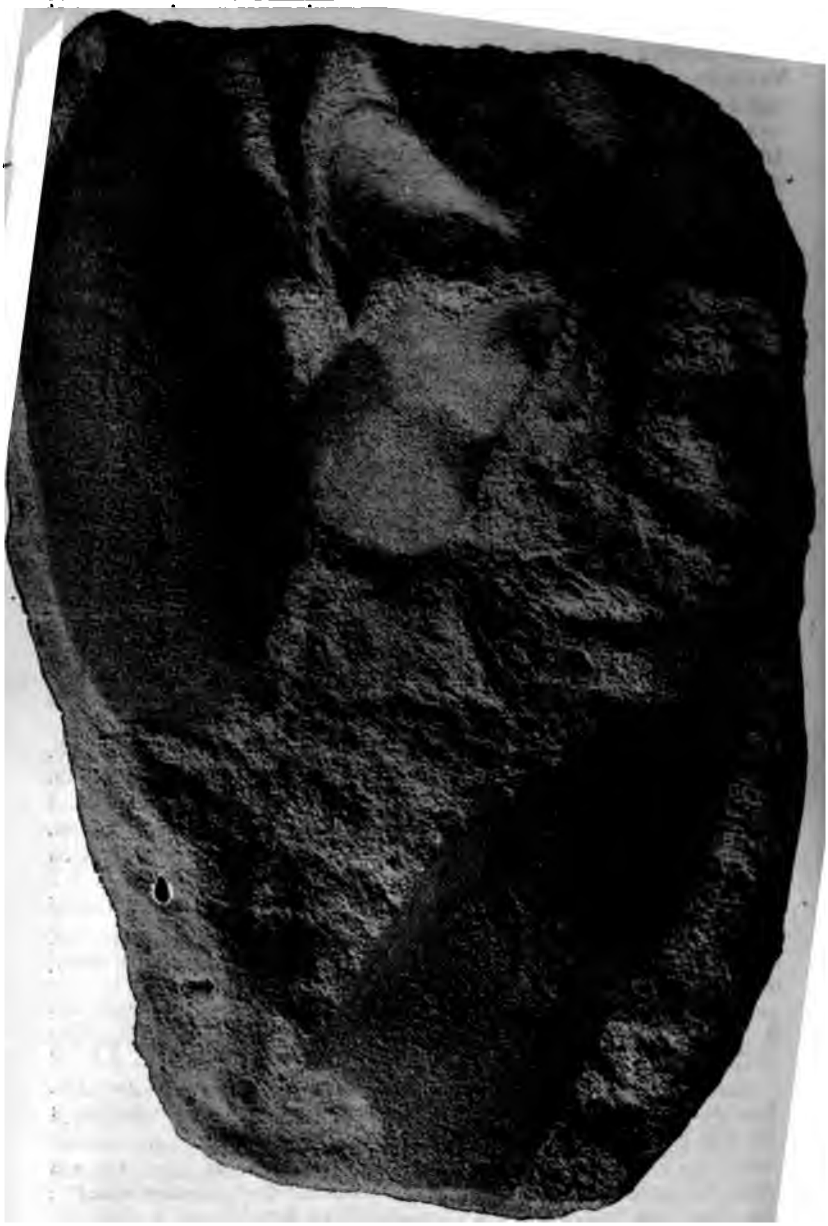
[3] Richard Howse, "Preliminary Notice of the Occurrence of *Archanodon* (*Anodonta*) *Jukesi*, Forbes, in the Lower Carboniferous Rocks of North Northumberland": Nat. Hist. Trans. Northumberland, vol. vii (1878), p. 173, pl. xiv.

[4] G. H. Kinahan: "Manual of the Geology of Ireland," 1878, p. 78.

[5] Richard Howse, "Note on the Priority of Discovery of *Archanodon* (*Anodon*) *Jukesi*, Forbes, in the Lower Carboniferous Rocks of North Northumberland": Nat. Hist. Trans. Northumberland, vol. vii (1880), pt. 2, p. 376.

[6] Edward Hull, "On the Geological Relations of the Rocks of the South of Ireland to those of North Devon and other British and Continental Districts": Quart. Journ. Geol. Soc., vol. xxxvi (1880), p. 255.

[7] W. B. Dawkins, "On the Range of *Anodonta Jukesi*": Trans. Manchester Geol. Soc., vol. xvi (1881), pt. 11, p. 247.



Archanodon Jukesi (Forbes MS.), Baily, sp.

Upper Old Red Sandstone, Llanvaches, Monmouthshire. Reduced one-third less th natural size; showing group of shells lying in matrix.

an interesting paper on *Anodonta Jukesi*, in which he compared the Irish and Northumberland habitats of this mollusc with the sandstone deposits of the Catskill Series of New York State, regarded variously as Upper Devonian or Lower Carboniferous, containing a large bivalve known as *Cypricardites Catskillensis*, and which he considered as a form closely analogous to *A. Jukesi*.

Professor Amalitsky[1] during 1895 established the new genus of *Palæanodonta*, selecting for his type *Unio castor* of Eichwald (Lethæa Rossica, 1861, p. 1,003, pl. xxxix, fig. 20), including in it, among other forms, *Anodonta Jukesi*.

Finally, it may be stated that the Monmouthshire specimen, now about to be described, was exhibited during the early part of 1895 at one of the meetings of the Geological Society of London,[2] and is referred to in the printed "Proceedings" as follows: "A specimen with *Anodonta* from the Lower Old Red Sandstone of Talgarth (Llanvaches), by Caerleon (Mon.), exhibited by Professor H. G. Seeley, F.R.S., on behalf of Percy Hawkins, Esq."

DESCRIPTION OF THE SPECIMEN.

Genus ARCHANODON, Howse, 1878.

Nat. Hist. Trans. Northumberland, vol. vii (1878), p. 173, pl. xiv.

TYPE.—*Anodonta Jukesi*, W. H. Baily.

SYNONYMS.—*Anodon*, E. Forbes MS., 1853; *Anodonta*, W. H. Baily, 1861; *Amnigenia*, Hall, 1883; *Palæanodonta*, Amalitsky (*pars*), 1895.

ARCHANODON JUKESI, W. H. Baily.

Anodon Jukesi, E. Forbes: 22nd Rep. British Assoc., 1853, p. 43.

Anodonta Jukesi, W. H. Baily: 28th Rep. British Assoc., 1859, p. 75; "Explanations to Sheets 147 and 157 of the Maps of the Geol. Survey of Ireland," 1861, p. 16, fig. 3.

Archanodon Jukesi, Richard Howse: Nat. Hist. Trans. Northumberland, vol. vii (1878), p. 173, pl. xiv.

Palæanodonta Jukesi, W. Amalitsky: Quart. Journ. Geol. Soc., vol. li (1895), p. 346.

The remains of this shell as represented on the sandstone slab from Monmouthshire consist of two casts or moulds of the interiors of left valves and a fragmentary right one. They have apparently escaped compression during fossilization, the original convexity of the specimens being well preserved. The valves are elongate, subcylindrical, convex, and sloping from the lateral summit to the ventral margin at an angle of about 20 degrees; anterior area rounded and short, posterior produced and obtusely angulated from the beaks to the margin; the umbones are depressed, not prominent, and very anterior; the cardinal line is edentulous, straight, and elongate, extending to within about 40 mm. of the posterior margin; the pallial and adductor scar impressions are only very feebly seen and almost incapable of proper definition, although the anterior adductor muscle impression is seen to be situated just beneath the upper margin of the shell, anteriorly and close to the umbone; surface ornamented at intervals with bold concentric growth-lines.

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[1] W. Amalitsky, "A Comparison of the Permian Fresh-water Lamellibranchiata from Russia with those from the Karoo System of South Africa": Quart. Journ. Geol. Soc., vol. li (1895), p. 346.

[2] Quart. Journ. Geol. Soc., vol. li (1895): Proceedings, p. vii.

DIMENSIONS. — Length, 140 mm.; height, 54 mm.; diameter (allowing for closed valves), 34 mm.

REMARKS. — The privilege has been accorded the writer by Mr. J. Nolan, of the Geological Survey of Ireland, of examining the original specimen from Kiltorcan, to which Forbes gave the provisional name of *Anodon Jukesi*, and which Baily at a later date described and figured as *Anodonta Jukesi*. This type, as well as other examples of the shell from the same locality, has suffered more or less from lateral compression during the period of fossilization, so that the valves are much flattened and shallow, differing in this respect from the beautiful convex form of the species as exhibited in the sandstone impressions from Monmouthshire. Somewhat similar conditions have affected the valves of the closely allied species *Amnigenia* (*Cypricardites*) *Catskillensis*,[1] the only mollusc found in the Oneonta Sandstone (= Upper Old Red Sandstone) of Chenango Co., New York State, and Hall's remarks in connection therewith are of interest to quote: "The various phases of this species seem to be all due to the degree and direction of pressure during the process of embedding" (Palæontology; Lamellibranchiata: Geol. Surv. State New York, 1885, p. 517).

Another fact of interest regarding the valves from Monmouthshire is their association with fish remains,[2] although only in a comminuted state and quite beyond determination.

In Ireland the mollusc occurs with *Palæopteris Hibernica*, etc., *Coccosteus*, etc., and *Eurypterus Scouleri*?, etc.; in Northumberland with *Ulodendron ornatissimum* and *Calamites*; and in America *A. Catskillensis*, the close ally of the British species, is found in company with plant and fish remains (*Holonema rugosum*).[3]

All these facts demonstrate that the genus *Archanodon* was of lacustrine or fluviatile origin, and that the deposition of the beds containing it, whether in England, Ireland, or America, must have been regulated by similar physical conditions and in close proximity to land. A good deal of discussion has transpired as to whether these Upper Old Red Sandstone rocks should be regarded as Upper Devonian or Lower Carboniferous, and it is hoped that the Geological Survey Memoir now in progress on the Monmouthshire neighbourhood may finally determine this point.

Notwithstanding its intimate relations with the *Anodonta* of modern times, there can be no doubt as to the desirability of recognizing Mr. Howse's name of *Archanodon* for this ancient species, although it has been so singularly overlooked by palæontologists. Its adoption will necessitate the extinction of *Amnigenia* of Hall, besides withdrawing the mollusc from the genus *Palæanodonta*, to which Amalitsky attached it in 1895.

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[1] Examples of this mollusc are exhibited in the Geological Department of the British Museum.

[2] On the authority of Mr. A. Smith Woodward.

[3] See Dana's "Manual of Geology," 1895, ed. 4, p. 618.

The following dimensions of the known examples of *Archanodon Jukesi* and *A. Catskillensis* (largest specimens selected) may be of interest for comparison:—

Archanodon Jukesi.—Ireland: length, 185 mm.; height, 75 mm.; diameter (allowing for closed valves), 24 mm. Northumberland: length, 228 mm.; height, 102 mm. Monmouthshire: length, 140 mm.; height, 54 mm.; diameter (allowing for closed valves), 34 mm.

Archanodon Catskillensis.—Length, 155 mm.; height, 67 mm.

Horizon.—The Monmouthshire specimens are in a matrix of reddish-brown sandstone grit of a somewhat coarse character, highly micaceous, and with a tendency to pulverize when handled. This formation was probably of contemporaneous deposition with the 'Yellow Sandstone' Series of the South of Ireland, and may consequently be regarded as of Upper Old Red Sandstone age, and not of a lower horizon as originally surmised when the present specimen was exhibited at the Geological Society.

III.—Note on *Ammonites euomphalus*, Sharpe.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

THE name *Ammonites euomphalus* was given by Sharpe[1] to an imperfect though unique specimen from the Lower Chalk, Man of War Cove, on the coast of Dorset. This example (according to Sharpe) originally belonged to E. H. Bunbury, Esq., but now forms part of the British Museum Collection [No. 50,158].

It is fairly well represented in the figures accompanying Sharpe's description, which is as follows:—"Shell gibbous, with a broad flattened back and angular whorls, crossed by numerous unequal tuberculated ribs, which bifurcate at the back; the ribs are about twenty in number on the side of the whorl, alternately larger and smaller; the larger ribs bearing a small tubercle near the umbilicus, and a strong spine at the edge of the back; the number of ribs on the back is about double that on the sides of the whorl, two springing from each spine, curving forwards and meeting again at the opposite spine; about every fourth dorsal rib is larger than the others, and bears two slight tubercles: umbilicus broad and funnel-shaped, leaving three-fourths of the inner whorls visible: aperture transverse and angular: septa with four very simple trifid, lateral lobes, and the lateral saddle very small."

As mentioned by Sharpe, the shell is "crossed by numerous unequal tuberculated ribs . . . . alternately larger and smaller . . . . the larger ribs bearing a small tubercle near the umbilicus, and a strong spine at the edge of the back," but the smaller ribs also have tubercles similarly situated, though relatively very much smaller than those on the larger ribs. The pairs of ribs which pass across the periphery and connect the strong spines on one side with those on the opposite side are thicker than the rest, the posterior one of each pair being the thicker of the two; this is especially the case where the diameter of the shell is 10 mm. At the middle of the periphery each rib bears a very feeble tubercle; on each side of this and about half-way between it and the large lateral spine, there is another rather more prominent, but still feeble, tubercle. The tubercles on the thickened ribs, especially on the posterior one of each pair connecting the large spines, are relatively larger than the rest.

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[1] D. Sharpe: "Foss. Moll. Chalk of England" (Mon. Pal. Soc.), pt. ii (1854), p. 31, pl. xiii, figs. 4*a–c*.

Sharpe gave the dimensions of the type-specimen as follows:—Diameter, three-fourths of an inch; width of aperture, half an inch; height of the last whorl, one-third of an inch. My own measurements of this specimen are:—Diameter of shell, 21·5 mm.; width of umbilicus (at suture of shell), 8·5 mm.; height of outer whorl, 8 mm.; height of outer whorl above preceding whorl, 6·5 mm.; thickness of outer whorl, 10·25 mm.

In 1896 Mr. A. J. Jukes-Browne recorded,[1] but did not figure, an example of this species from the "sandy chalk, Bed 13 of Mr. Meÿer, in the cliff below Whitlands coastguard station, west of Lyme Regis." This specimen belongs to the Survey collection at Jermyn Street Museum, and is represented in the accompanying figures (Figs. 1*a–c*). It is completely septate, and has a diameter of 40·5 mm., being therefore much larger than Sharpe's type-specimen. Owing to the imperfection of the anterior part of the fossil its dimensions can be best taken at a diameter of 38 mm. These are:—Diameter of shell, 38 mm.; width of umbilicus (at suture of shell), 15 mm.; height of outer whorl, 14·5 mm.; height

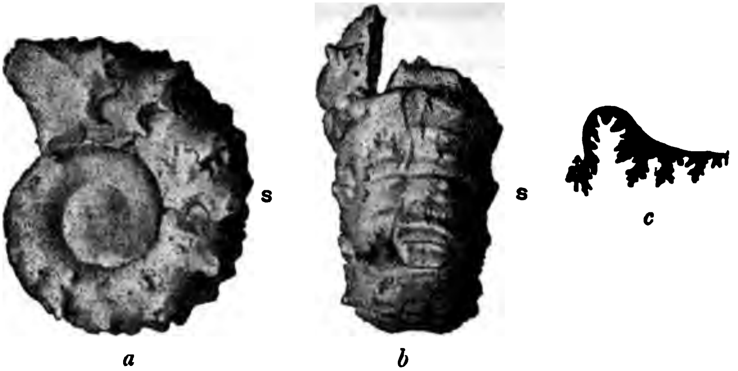

FIG. 1.—*Douvilléiceras euomphalus* (Sharpe).—*a*, lateral view; *b*, peripheral view of the same specimen; *c*, suture-line of the same example as seen at the place marked *s* in *a* and *b*. From "sandy chalk, Bed 13 of Mr. Meÿer, in the cliff below Whitlands coastguard station, west of Lyme Regis." Drawn of the natural size from an example in the Museum of Practical Geology.

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[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 155.

of outer whorl above preceding whorl, 13·5 mm.; thickness of outer whorl (excluding spines), 21·5 mm. The specimen is fairly well preserved; the inner whorls are, however, imperfect on one side, and on the other obscured by matrix if present. The suture-line is displayed where the fossil has a diameter of 33 mm.; it is represented in Fig. 1*a*. One side of the earlier portion of the outer whorl bears marks of an injury during the life of the animal.

So far as I know, these are the only two examples that have been recorded as belonging to this species.

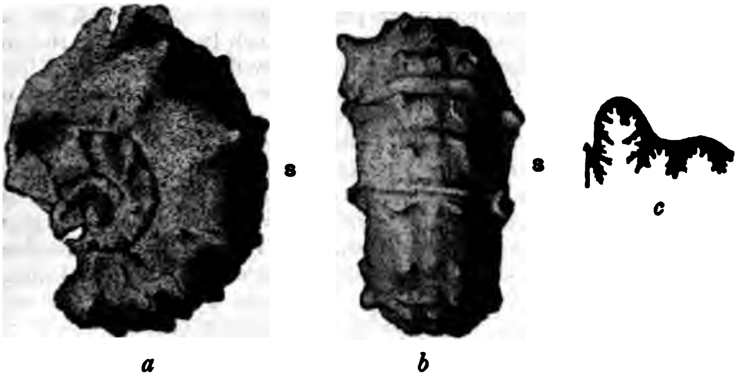

Fig. 2.—*Douvilléiceras euomphalus* (Sharpe).—*a*, lateral view; *b*, peripheral view of the same specimen; *c*, suture-line of the same example as seen at the place marked *s* in *a* and *b*. Lower Chalk: Humble Point, close to Whitlands, west of Lyme Regis. Drawn of the natural size from the example in the British Museum (Nat. Hist.) that was collected and presented to the Museum by Dr. Rowe and C. D. Sherborn, Esq.

Among some Chalk fossils recently collected by Dr. Arthur Rowe, F.G.S., and Mr. C. Davies Sherborn, F.G.S., from the "hard nodular Cenomanian Limestone with grit and green grains, half a mile from the shore at Humble Point, close to Whitlands (west of Lyme Regis), Devonshire," there is a specimen which I consider to be referable to Sharpe's species (see Figs. 2*a*–*c*). Being entirely septate, and therefore incomplete, it does not furnish the characters of the adult shell; nevertheless, it is a particularly interesting specimen, for being larger than either of the previously recorded examples, the characters which it displays more nearly approach those of an adult shell. A portion of the outer whorl is missing, but the rest of the fossil is well preserved; the inner whorls are present, and the suture-line is shown. The dimensions of the specimen are:—Diameter of shell, 43 mm.; width of umbilicus (at suture of shell), 16 mm.; height of outer whorl (excluding spines), 16 mm.; height of outer whorl above preceding whorl, not seen; thickness of outer whorl (excluding spines), 23 mm. The inner whorls up to a diameter equal to that of Sharpe's type-specimen can be plainly seen; they are fairly well preserved. The shell passes from a diameter of 21·5 mm.—the diameter of the type-specimen—to its greatest diameter, viz. 43 mm., in about three-fourths of a whorl. The first fourth of this portion is wanting. The last half-whorl is well preserved; on its lateral area the smaller ribs completely disappear, while the spines on the larger ribs become relatively larger, the inner one only slightly, but the outer one considerably. The pairs of strong ribs on the periphery connecting the large lateral spines are well developed. Of the tubercles on the anterior rib of each pair, that on each side of the median line of the periphery becomes with age relatively much smaller, while the corresponding tubercle on the posterior rib becomes much larger, the rib itself becoming at the same time much less distinct; the rib at the anterior lateral spine that is preserved is very feeble. The intermediate ribs almost entirely disappear at the anterior part of the specimen; the tubercles on the rib which is situated about half-way between two lateral spines gradually increase in size, especially the one on each side of the median line, that on the median line being well marked, but smaller and more obtuse than the others. With considerable difficulty the suture-line has been traced on this portion of the fossil, namely, at the point marked *s* in Figs. 2*a*, *b*, where the diameter of the shell is about 34 mm.; it is represented in Fig. 2*c*.

Although this specimen considerably increases our knowledge of Sharpe's species, we are not yet in a position to give the characters of an adult shell.

As will be seen from a comparison of Figs. 1 and 2, there are certain differences between the originals of the two figures. A very obvious difference is in the number and size of the lateral spines. The example represented in Fig. 2 has fewer and relatively stronger spines than the original of Fig. 1; the former has only five large lateral spines in the last half of the outer whorl, whereas the latter has twelve large spines in the outer whorl, seven of these being in the last half-whorl. Unfortunately the inner whorls of the example represented in Fig. 1 are not well preserved, but their ornaments seem to agree very closely with those of the type-specimen, the spines on the inner whorls of the original of Fig. 2 being relatively further apart. There are also differences between the suture-lines of the two specimens; some of these may be due to the spiny character of the shell, the suture-line varying somewhat according to the position of the septum with regard to the spines. The specimens were, however, found at the same locality and on the same horizon; hence, notwithstanding the differences just mentioned, we are inclined, in the absence of more satisfactory material, to refer these examples to the same species, the example depicted in Fig. 1 being probably more like the adult of Sharpe's type than the original of Fig. 2.

In regard to the affinities of this species, Sharpe correctly pointed out that it was allied to *Ammonites Martinii*, D'Orbigny,[1] a species

[1] *A. d'Orbigny*: Pal. Franç. Terr. Crét., vol. i (1841), p. 194, pl. lviii, figs. 7-10.

belonging to the group for which Grossouvre has proposed the generic name *Douvilléiceras*,[1] the type species being *Ammonites mammillatus*, Schlotheim.[2] It is evidently closely allied to the *Acanthoceras aberrans* of Kossmat,[3] who regarded that species as an aberrant member of the genus *Acanthoceras*. That species appears to be very rare, for only a single example is known, and that came from the Middle Utatur Group of Odium, South India—a group containing numerous *Acanthoceras* of the group of *Rothomagense*, Defrance, and *Mantelli*, Sowerby, as well as *Turrilites costatus*, Lamarck, etc., and referred by Dr. Kossmat to the younger portion of the European Cenomanian. Neumayr[4] referred the present species to his genus *Hoplites*.

There can, we think, be no doubt that this species is closely allied to the genus *Douvilléiceras*, and we think it may be placed, at least provisionally, in that genus. Sharpe's type-specimen came from the Lower Chalk, Man of War Cove, on the coast of Dorset, but the Cephalopoda occurring in association with it are not recorded. From the bed in Devon which contained the example of this species referred to by Messrs. Jukes-Browne and Hill, these authors record the following Cephalopoda (the species marked S having been collected either by themselves or by Mr. Rhodes for the Geological Survey, and those marked M having been identified by Mr. Meÿer from specimens in his own collection) :—

Belemnitella plena, Blainville	S M
Nautilus Fittoni, Sharpe	S
,, *Deslongchampsianus*, D'Orbigny	M
Ammonites euomphalus, Sharpe	S
,, *Goupilianus*, D'Orbigny	M
,, *hippocastanum*, J. de C. Sowerby	S M
,, (?) *leptonema*, Sharpe	M
,, *navicularis*, Mantell	S M
,, *pentagonus*, Jukes-Browne	S
,, *planulatus*, J. de C. Sowerby	M
,, *Renevieri*, Sharpe	M
,, *rothomagensis*, Defrance	S M
Scaphites æqualis, J. Sowerby	S M
,, ,, var. *obliquus*, J. Sowerby	M
Turrilites Bechei, J. Sowerby	M
,, *tuberculatus*, Bosc	M
Hamites simplex (?), D'Orbigny	M

From the *same* block which yielded the example of *Douvilléiceras euomphalus* referred to above, Dr. Rowe and Mr. Sherborn obtained the following Cephalopoda, as well as one or two apparently undescribed forms :—

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[1] A. de Grossouvre, "Les Ammonites de la Craie supérieure": Mém. Carte géol. détaillée de la France, 1893, p. 26.

[2] E. F. v. Schlotheim: Min. Tasch., vol. vii (1813), p. 111.

[3] F. Kossmat, "Untersuchungen über die südindische Kreideformation": Beitr. Pal. Geol. Österreichs-Ungarn, etc., Bd. ix, Hft. 3 and 4 (1895), p. 202, pl. xxiv [x], figs. 4*a*–*e*.

[4] M. Neumayr, "Über Kreideammoniten": Sitzb. d. k. Akad. d. Wissensch., Wien, Bd. lxxi, Abth. 1 (1875), p. 685.

Nautilus expansus, J. de C. Sowerby.
,, *Largilliertianus*, A. d'Orbigny.
Acanthoceras hippocastanum (J. de C. Sowerby).
,, ,, ,, , var. *compressa*, Jukes-Browne.
,, *Mantelli* (J. Sowerby).
,, *naviculare* (Mantell).
Schloenbachia Goupiliana (A. d'Orbigny).
,, *varians* (J. Sowerby).
Placenticeras Largilliertianum (A. d'Orbigny).
Scaphites æqualis, J. Sowerby.
,, ,, ,, var.
Baculites, sp.

IV.—Notes on certain Granitoid Fragments from the Culm Conglomerates, and Tourmalinized Grits from the New Red Conglomerates of South Devon.

By Arthur R. Hnut, Esq.

WHEN studying the Dartmoor Rocks some years ago I was anxious to ascertain whether any fragments referable to Dartmoor could be detected in the Culm conglomerates and Culm sandstones of South Devon. Sections cut from these rocks, collected for me by my friend Mr. W. A. E. Ussher, F.G.S., proved in every way so dissimilar from Dartmoor rocks and minerals that further investigation in that direction appeared useless. About the same time I collected a variety of fragments from the New Red breccia at Labrador, near Teignmouth, while Mr. Ussher supplied me from other localities. These, again, even when schorlaceous, differed so much from any rocks known to me that I postponed further inquiry in that direction also *sine die*. The facts seemed important, but the clue to their interpretation was wanting. During the past year Messrs. A. Somervail and Harford Lowe, Hon. Secretary and Hon. Treasurer of the Torquay Natural History Society, have been fortunate enough to obtain a number of specimens of a very fine-grained granitic rock among the pebbles of the Culm conglomerate in the neighbourhood of Roydon, South Devon.[1] These interesting rocks they have been good enough to submit to me for examination, with a view to ascertaining how they compare with the well-known types of the Dartmoor granites. Mr. Teall has also kindly lent me a slide cut from one of Mr. Somervail's specimens in his possession. I have seen altogether six slices of different specimens of the Culm conglomerate granites.

My knowledge of petrology does not warrant a technical description of the slides with identification of the felspars, so such will not be attempted. The six slides, though slightly differing, present a very strong family likeness and are all very fine in grain. One or other of them presents the following marked distinctions from any ordinary type of Dartmoor rocks known to me:—

(1) A tendency to a parallel arrangement of quartz and mica.
(2) Micro-porphyritic microcline and plagioclase, in a finer matrix.
(3) Felspars, occasionally bent.

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[1] See A. Somervail, Geol. Mag., Dec. IV, Vol. V, p. 509.

(4) Strongly marked strain shadows in quartzes, more rarely seen in felspars.

(5) The fluid inclusions in quartzes very minute, with absence of chlorides.

(6) Absence of tourmaline.

Exception may perhaps be taken to No. 4, as strain shadows are strong in the veins of granite which intersect the Culm grits. But these are peculiar. The only case of equally strong strain shadows within the borders of Dartmoor known to me is shown in a slice from the neighbourhood of Brent Tor. But that locality may also be said to be peculiar. Taking texture alone, it would not be easy to find a Dartmoor granite as fine in grain as the fragments from the Culm conglomerate; and so far as my experience goes it would be extremely difficult to find a Dartmoor rock without either a trace of tourmaline as a mineral constituent or a trace of chlorides caught up by the quartzes.

I believe General McMahon, after considerable experience of Dartmoor, has observed that at the time of writing he had never seen a specimen without tourmaline. I may say that I have never yet examined a slide from Dartmoor which did not reveal traces of salts crystallized in the fluid inclusions, though in one or two cases these almost eluded detection. As a rule, wherever there is tourmaline in abundance in a Dartmoor crystalline rock there will also chlorides be found in abundance. Not so in the contact grits; there tourmaline seems to abound without the chlorides.

The differences between the Culm granite fragments and the Dartmoor rocks are sufficiently remarkable, but still more so is the fact that none of the innumerable varieties of Dartmoor rocks and minerals have been detected in the Culm conglomerates and sandstones. I have never seen a grain of felspar, mica, or quartz in the Culm rocks of which one could say, that it probably came from Dartmoor.

While engaged in examining the Culm granitic fragments I received in due course the Abstract Proceedings of the Geological Society for February, 1899, containing a notice of Mr. A. E. Salter's paper on Pebbles of Schorl Rock from the South-West of England, and Professor Bonney's observation that Mr. Salter's pebbles resembled certain tourmalinized sedimentary rocks which occurred in the South-West of England and in the Budleigh Salterton conglomerate. This paper, coming when it did in the nick of time, interested me greatly, and Mr. Salter was kind enough to send me a few scraps of his pebbles. In one of them, to my great surprise, I recognized my anomalous schorlaceous rock from the Labrador breccia. Mr. Salter then favoured me with a sight of his slides. They seemed to me to show that one great Devonshire problem had been solved, viz., the origin of some of the doubtful fragments of the New Red breccias.

By diagnosing Mr. Salter's pebbles, Professor Bonney had cleared up a difficulty I had despaired of ever seeing explained. Of course, it is easy to be wise *after the* event, so it was no surprise to find

I had in my own collection of slides the whole chain of evidence from beginning to end.

My own series consists of one contact slide, granite-and-grit, from near Bovey Tracey, one granite-and-grit from near Lustleigh, three fragments from New Red of Labrador, two near Ideford, two near Yeoford, and two, strangely enough, from the Brixham raised beach. They are all members of one remarkable family.

Comparing my own slides in the light of Mr. Salter's, I noticed that both my contact slides had in their granite portions well-marked crystals of idiomorphic brown tourmaline. On close examination minute crystals of the same brown tourmaline could be seen pervading the interstices between the quartz granules of the Culm-grit portions of the slides. A similar invasion by tourmaline was then noticed, both in Mr. Salter's pebbles and in my specimens from the New Red conglomerates. In some cases the aluminous cement of the quartz granules seemed transformed into tourmaline. The tourmaline in the conglomerate fragments is chiefly a bluish-green variety, whereas that in my contact slides is brown.

Of Mr. Salter's specimens I cannot, of course, speak, nor have I retained a single note of them. I cannot refrain from saying as much as I have, as never before in my experience has the comparison of notes thrown so much light into an absolutely dark corner.

It is abundantly evident that all these tourmalinized grits are the débris of the rocks once immediately covering the great granitic areas of the West of England. Grits once plutonic, permeated at high pressure by the mineralized waters which filled the fissures in the granite with the well-known felspar-quartz-schorl veins. Such action on a grit results in a very deceptive altered rock, which may be anything between a sedimentary rock and a crystalline one, but all with the common link of tourmaline running through them, and tourmaline very unlike the types usually occurring in the granitoid rocks, where crystallization has not been so much hampered by the original minerals of the sedimentary rock; while, in the veins, crystallization has been quite unimpeded.

In the case of a tourmaline vein, it is often easy to see that the mineral is as original as the quartz accompanying it. A fissure existed, and freshly crystallized minerals occupied the space. But in the case of mineralized waters attacking the aluminous or felspathic matrix of a grit, it is not easy to distinguish to what extent the newly-formed tourmaline is derived from the pre-existing felspathic element, or from the invading fluids, which, perhaps, in a neighbouring vein prove themselves quite capable of forming felspar quartz and tourmaline without any outside assistance; whereas the felspar alone could supply neither boron nor fluorine. Tourmaline is truly a protean mineral occurring in various forms, each form no doubt arising from its own peculiar originating cause.

The non-schorlaceous granites of the Culm conglomerates, coupled with the schorlaceous grits of the New Red conglomerates, suggest *quite* a number of interesting problems. The Culm conglomerates *bear witness* that no portion of the Dartmoor granite, or of its immediately covering grits, was at that time undergoing denudation. The Labrador volcanic breccias, as they have been called, bear witness to the fact that during their accumulation the covering grits were being largely demolished, the granite sparingly, if at all. Now, assuming these breccias to be Permian, would it not be possible to trace the gradual uncovering of the Western granites by the character of the débris found throughout the newer beds of the Red Sandstones? A very arduous task, no doubt, but an interesting one. Then the schorlaceous rocks of such distant localities as Teignmouth, Budleigh Salterton, and the Midlands, should be carefully compared. Perhaps the first question to get answered is—Is there any region known, except the West of England, which produces crystalline schorlaceous rocks crammed with chlorides; and fine grits, saturated, so to speak, with tourmaline?

I need not say what a very important bearing these tourmalinized grits have on the volcanic theory of Dartmoor. Were the Dartmoor rocks first exposed to denudation, the once plutonic tourmalinized grits; or were they the higher lavas and ashes of a volcano? They cannot very well have been both. Then how are we to reconcile the apparently early appearance of these covering grits in the conglomerates with the famous Cattledown hypersthene-andesites found by the late Mr. R. N. Worth, and referred by him to an ancient Dartmoor volcano? Dartmoor is a wondrous easy problem if we suppress inconvenient evidence. But hear all sides, and it is a tough nut to crack.

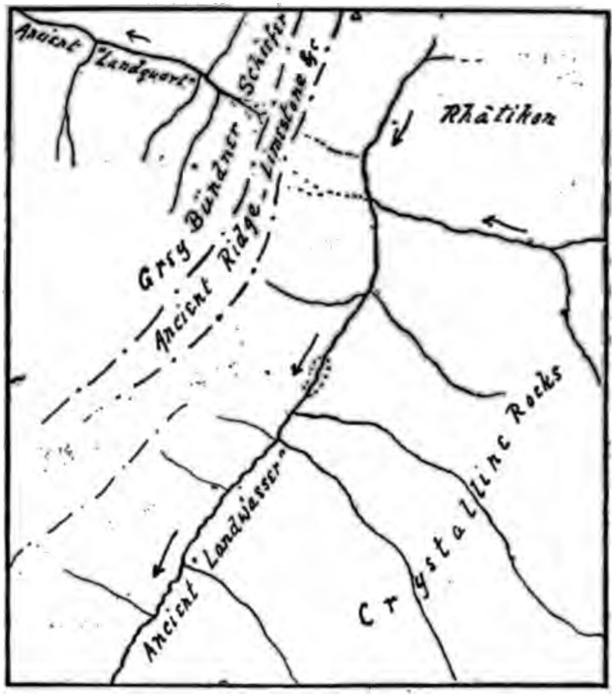
In conclusion, I cannot refrain from expressing my admiration of the pertinacity with which my friends, Messrs. Somervail and Lowe, have so continuously attacked the Culm conglomerates. These granitic fragments are entirely new facts, and facts which may lead to a good many more, and one real new fact about Dartmoor is worth a volume of theories, however large such volume may be.

V.—ON THE COURSES OF THE LANDWASSER AND THE LANDQUART.

By A. VAUGHAN JENNINGS, F.L.S., F.G.S.

CASES of relatively recent change in the courses of rivers, due to the invasion of their valleys by neighbouring and more rapidly working streams and the consequent diversion of their waters, have been investigated of late years by an increasing number of geologists in different countries. Such phenomena are, of course, most frequent in mountain districts, and the Swiss Alps have yielded many examples of greater or less certainty. Some cases are evident and undeniable; others are difficult to decide upon, and need careful consideration of all available evidence; while in yet other instances it is possible that statements as to the occurrence of such changes have been accepted on inadequate authority. The generally received opinion as to the present and past relationship of the Landwasser and the Landquart can certainly not be included in the last category, but neither can it, I think, be rightly placed in the first.

The Landquart is a river of Northern Graubunden which now flows from the *glaciers of the* Silvretta group northward and westward through the fertile Prätigau to join the Rhine betw Chur and Ragaz. Near the village of Klosters, where the narro valley of its mountain course widens into the ampler trough of Prätigau, it receives two tributaries. From the north flows int the Schlappina, rising behind the rugged mass of the Eas Rhätikon; on the south opens a side valley, which, when follo up, is found to lead to the saddle that now closes the northern of the famous 'valley' of Davos. The stream which appare



I. Former drainage of the Davos district according to Prof. Heim.

descends from this saddle proves to be formed by the union of one from the east and one from the west,[1] but there is none flo directly from the broad pine-clad divide between Wolfgang and Drusatch Alp. On the south side of this curious 'Kulm' lies deep Davoser See, and into the long, almost level alluvial which succeeds it flow three rivers—the Fluela, the Dischma, the Sertig. The Fluela and the Dischma enter near together be the south end of the lake, and form, with the insignificant out of the lake, the origin of the Landwasser. Five miles below the lake, but only at a level of thirty metres below its surface, the Landwasser is joined by the Sertig, which flows also northward and westward from its source among the snows of the Ducan. Thus reinforced the Landwasser flows on past Frauenkirch and Glaris, and through the Züge gorge, finally joining the Albula, and so in time also reaching the Rhine.

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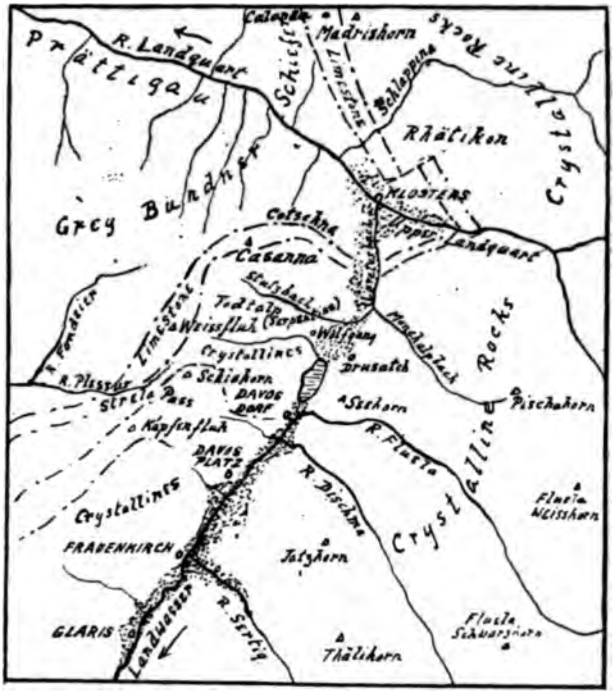
[1] The streams are the Mönchalpbach and the Stützbach; the result of confluence I have called the Lareterbach, but find that on some maps it is calle Stützbach down to Klosters.



II. Present drainage of the Davos district.
Scale 1:250,000

Professor Heim considers that this distribution of the two rivers and their tributaries does not represent the original drainage conditions of the area. He is of opinion that the valley of the Landwasser once extended northward above the present site of Klosters, and that its river was continuous with that rising at the head of the Schlappinathal.[1] The western side of this valley consisted of a rock-wall continuous with the masses now remaining on either side of the Prätigau—the Mädrishorn and Calanda on the north and the Casanna and Cotschna on the south. This wall, on the hypothesis in question, was cut through by the head waters of the river which then occupied the Prätigau, and was eroding its source more rapidly than the ancient Landwasser could deepen its bed. The result was that the latter was cut into by the former, and its waters, with those of its upper tributaries, diverted into the channel of the pirate stream.

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[1] "Mechanismus der Gebirgsbildung," p. 321.

This theory has, I believe, been accepted by geologists in general both in Switzerland and elsewhere. It has been incorporated by Professor Tarnuzzer in his revised edition of Theobald's "Naturbilder aus der Rhätischen Alpen," and it has been made widely known to English readers by its inclusion in Sir John Lubbock's "Scenery of Switzerland."[1]

It may seem rash to question a view put forward by so high an authority and so strongly supported; but as I have already to some extent committed myself to an opinion on the subject,[2] it is perhaps both justifiable and advisable that I should point out the considerations which, during several months' study of the district, have seemed to me to weigh against its too ready acceptation.

The conditions which, according to the hypothesis, existed before the diversion of the ancient 'Landwasser' are shown in Fig. 1. Even at first sight there seems here something different from the usual type of river origin. There is an absence of the tree-like structure, of the oblique convergence of tributaries that one associates with the upper waters of a drainage system, while the northward trend of the main feeders from the east seems distinctly exceptional.

Leaving these difficulties aside, however, for the present, and observing the sources from which the river would have been supplied, it is evident that the ancient 'Landwasser' must have possessed a current of considerable volume and great erosive power. The present Landwasser, fed from the mountains of the Scaletta and Ducan districts, is no mean excavating agent in the Frauenkirch-Filisur valley, but its predecessor would have had in addition the whole force of the 'Upper Landquart,' the drainage of the snow and icefields of the great Silvretta group. We may therefore be reasonably sure that such a river would be rapidly deepening its channel and tending to add to the relative height of its western wall.

The question then arises as to the nature of the stream on the other side of this barrier, and whether it is likely to have had the erosive force requisite even to keep pace with its powerful neighbour. It is difficult to imagine that such can have been the case. The lower Landquart is supplied by numerous streams from the side valleys of the Prätigau, but these enter it approximately at right angles from north or south, and their representatives at that time could have taken no part in the denudation of the transverse cliff-like outcrops at the head of the system. When the rock ridge stretched across from the Mädrishorn to the Casanna the head waters of the Landquart would have been only the little rivulets rising on the western face of the ridge of itself. The Landquart between Klosters and Serneus owes its existence, according to the theory itself, to the removal of the barrier ridge, and cannot therefore be regarded as the cause of that removal. There were doubtless small streams at work on the east side of the ridge (as suggested by the dotted lines in Fig. 1), but it is difficult to understand how there could have been any river describable as the former 'Landquart' engaged in its destruction.

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[1] *London, 1898*, p. 190. [2] Quart. Journ. Geol. Soc., vol. liv; August, 1898.

The conditions which then existed may be paralleled at the present day by the source of the Plessur, a short distance to the south. This river is an important one in the Schanfigg valley after the lateral influx of the Fondeier and the Arosa-wasser: its upper waters are insignificant, and originate in a rivulet between the Weissfluh and the Schiahorn. The limestone ridge of the Schiahorn and Kupfenfluh here occupies just the same position in relation to the Davos and Plessur valleys that the ancient ridge at Klosters did to the Landwasser and Prätigau. Between the two mountains the ridge is lowered where it is traversed by the Strela Pass, but there is practically no running water at work on the western face at this point, and no evidence of denudation except that of atmospheric agents and the cutting of the Schiabach on the east. Sir John Lubbock,[1] it is true, suggests that "It is possible that in the distant future the Landwasser may be still further robbed of its territory. The waters of the Davos Lake, the Fluela, the Dischma, and the Kuhalpthal now take a very circuitous route to Chur, and it is not impossible that they may be captured and carried off by the Plessur."

Such a change may appear conceivable when considered only with the aid of sketch-maps, but I venture to think that anyone who carefully observes the contours or studies the locality in person, will find it very difficult to imagine its possibility. At its lowest the limestone ridge is 2,000 feet above the Landwasser at Davos, and, as pointed out above, is suffering no specially rapid denudation. On the other hand, the Landwasser is a considerable current which under normal conditions would be constantly lowering its level and so relatively adding to the height of the divide between it and the Plessur basin. It seems to me that a similar condition of things would have existed in the Klosters neighbourhood according to Professor Heim's theory.

It may be argued that some geological peculiarity of the district may have contributed to a rapid destruction of the ridge. It is true that the neighbourhood is one of complex structure — of the rapid thinning of some strata, and of folds and faults, torsion and overthrust. The hypothetical ancient 'Landwasser,' however, seems to have followed its own course independent of the disturbed strike of the strata and uninfluenced by the variety of rocks through which it cut, and we have no reason for supposing any special conditions that would have assisted its rival. Had there been any important line of weakness running east and west, the north-and-south course of the Landwasser would scarcely have been in the first instance established.

[1] "*Scenery of Switzerland*," p. 192.

Again, a study of the geological map may suggest that the rapid back-cutting of the Landquart was due to the more rapid erosion of the grey Bündner Schiefer of the Prätigau, in comparison with that of the crystalline rocks, limestones, etc., which formed the bed of the 'Landwasser.' The grey Bündner Schiefer, however, lay only at the base of the ridge, and it is the through-cutting of the ridge itself that is the difficulty. It was only after the cutting of the ridge that the Landquart would in the critical area have arrived at the underlying shales, and this brings us to a consideration of the nature of the ridge itself.

Although the district is a difficult one, owing to its being the point at which the simple outcrop-line of stratified works running south-east to Klosters from the Scesaplana district passes into the complex folds traceable near Davos, yet a study of the present outcrops of the various formations gives us a fairly accurate idea of what must have been the structure. Its most conspicuous feature was doubtless the band of 'Hauptdolomit' now seen to form the Casanna on the south of the Prätigau and the Calanda on the north. A line drawn from the present top of the former, doubtless then considerably higher, to the upper limit of limestone on the latter gives a height above the sea of 2,650 metres. This would be about 4,800 feet above the present level of Klosters, and 2,800 feet above the Drusatch Alp. The limestone series was accompanied by a greater or less thickness of Verrucano and Casanna Schiefer, with probably a band of serpentine; and the whole series was thrust over the grey Bündner Schiefer, which dipped south and east below it. Above the limestone and its associated rocks there was in all probability a capping of the schists and gneisses belonging to the older crystalline series, such as now overlie it to a vast thickness on the Eastern Rhätikon, and still remain to form the peak of the Mädrishorn. What may have been the thickness of this crystalline covering it is impossible to say. Even, however, if we suppose it to have been removed before the period under consideration there would still remain a barrier of a height and constitution to render it a formidable task for a few rivulets to attempt in competition with the forceful river on its further side.

Lastly, when one considers that the ancient 'Landwasser' represented not only the combined Schlappina, Upper Landquart, and Landwasser of to-day, but almost certainly a far greater volume of water owing to the wider extent of the snow and ice-fields on the eastern mountains—a difference of conditions that would not have had proportionate effect on the Calanda-Cotschna ridge — the inequality between the two agencies at work becomes still more conspicuously marked.

Such are some of the difficulties which, it seems to me, one must overcome before accepting Professor Heim's view. When we endeavour to get an idea of the bed of the ancient 'Landwasser,' and attempt to derive from it the present conditions between Klosters *and the* Davos-Glaris region, we meet with considerations no less difficult to reconcile. To appreciate these it is necessary to observe some of the peculiarities of the Davos 'valley.'

If we follow up the Lareterbach from Klosters we find it descends in a steep valley with solid rock on the east and a great accumulation of moraine and detrital material on the west. Some three miles up, near Laret, it curves west, and is seen to descend from the pass between the Casanna and the Todtalp. Just below this bend it receives the Mönchalpbach, flowing from the Pischa glacier on the east, but there is no stream descending in the middle line of the valley. Half a mile south of the Stützbach is Wolfgang, the 'Kulm' of the Davos 'valley,' 1,634 metres above the sea, or 425 above Klosters. West of Wolfgang is the serpentine mass of the Todtalp, lying back at some distance but with a great talus-fan at its foot, which spreads over the Kulm and has apparently forced southward the stream of the Todtalpbach. East of Wolfgang lies the remarkable rounded and tree-covered elevation which stretches transversely across the valley and reaches a height of 1,776 metres at the Drusatch Alp, where it abuts against the schists and gneisses of the Hörnli.

The southern slopes of this ridge descend to the Davoser See, which is a mile in length and about half as much in width. While popular tradition as to the depth of the lake is undoubtedly exaggerated, the evidence of sounding and of calculation from the slopes of the surrounding mountains, leaves no doubt that the bottom is some 150 metres below the surface at the deepest point, about a third of the length from the north end. The south end shallows rapidly and terminates in the low-lying meadows around Dorf, which in turn are continued into the alluvial flat stretching on past Davos Platz. Into these meadows flows the Fluela, and its now canalized course, turning southward and receiving the little stream issuing from the lake, forms the origin of the Landwasser of to-day. Increased in volume by the influx of the Dischma, the Landwasser flows on, with but little drop, to Frauenkirch. Here it lies on the western side of the valley, and on the east a vast accumulation of detrital material marks the mouth of the incurrent Sertig. This mass presents a steep bank 30 metres high to the river, and is cut out above into the wide flat terraces of the Wildboden and Junkersboden. The level of these terraces is just the same as the present level of the lake, so that the height of their terminal bank represents the total fall of the Landwasser in the first five miles of its course. Below Frauenkirch the river, no longer canalized, pursues a winding course past Spinabad, Glaris, and Monstein, and then plunges into the gorge of the Züge. As far as Glaris it is flanked on the west by great masses of detrital material, but soon after passing that village it flows practically on its true rock bed.

In a paper published last year[1] I called attention in greater detail to these general features of the Davos area, and also pointed out—

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[1] Vaughan Jennings, "On the Structure of the Davos Valley": Quart. Journ. Geol. Soc., vol. liv (1898).

(1) That the Landwasser was not running as at present when the detrital fan opposite Frauenkirch accumulated, since a portion of that fan still exists on the west side of the valley, separated from the main mass by a subsequent down-cutting.

(2) That as the whole bed of the Upper Landwasser lies on alluvial and detrital material its present course gives no indication of the real contour of the rock-floor; and the latter may, and probably does, slope northward.

(3) That a comparison of the slopes of the mountain sides at a series of points along the Davos area also gives support to this suggestion.

(4) That the ice-movement in the district was certainly northward.

(5) That solid rock *in situ* cannot be found on the Wolfgang-Drusatch ridge, and that this feature in the landscape probably consists entirely of moraine material, mainly ice-borne from the Todtalp.

The conclusions which I based on these observations were as follows:—(1) That in Pre-Glacial times the Fluela, the Dischma, and perhaps the Sertig, flowed northward into the Landquart. (2) That in Post-Glacial times the presence of the Wolfgang-Drusatch mass and the detrital accumulation round Clavadel and Frauenkirch—then, as I have shown, far greater than now—caused the formation of a lake between these two points, probably with an outflow over Wolfgang. (3) That in time the work of the Landwasser below Frauenkirch, and perhaps of the Sertig also, so weakened the southern dam as to cause an outflow of the lake in that direction, carrying with it the waters of the Fluela and Dischma.

In making these suggestions I did not fully realize the extent to which they were connected with the whole question of the past history of the rivers; nor did it occur to me that some geologists would be willing to accept the idea of the former northward flow of the eastern tributaries, while still holding not only to Professor Heim's view but also to a belief in a solid rock ridge between Wolfgang and Drusatcha. I may, therefore, perhaps be allowed to say something in support of the conclusions I then arrived at before pointing out their bearing on the main question under consideration.

It has been objected by some that the detrital accumulations opposite Frauenkirch are mainly of a fluviatile character, and as a whole are not of sufficiently compact and massive character to have held up the waters of a great lake. We have exposed here, however, only what is probably a fringe of lighter material round the edges of a mass of coarser detritus. There are abundant examples near Clavadel of large rock-fragments ice-borne down the Sertig valley. It is also by no means necessary to suppose that the southern dam was merely a transverse barrier at this point. It is very probable that the whole valley was choked with débris as far south as Monstein. The enormous thickness of detritus full of ice-borne blocks which occurs at that village doubtless once crossed the *Landwasser* valley and abutted against the western cliffs of the *Züge*. In the same way the banks and terraces of the Langmatter district are cut out of a mass that probably once stretched across the valley, and was heaped up against the slopes of the Rinnerhorn. We have here an amply sufficient amount of material to have supported the lake. The *fact* of the former southerly extension of the lake is generally accepted and perhaps undeniable,[1] but there seems no other way of accounting for its existence than that here suggested.

Secondly, as to the nature of the Wolfgang-Drusatch barrier. When I made the suggestion above referred to I based my conclusions on physiographic grounds only. The form and position of the mass and its overgrown character, offering a striking contrast to the bare and weathered Todtalp of which it has been regarded as an extension, suggest anything but an ancient ridge of rock exposed to denudation since Pre-Glacial times. It is evident that an immense amount of material must have been removed from the east of the Todtalp; yet we do not find great accumulations of serpentine in the lower valleys. Evidence of extensive glaciation is, as Theobald specially noticed, abundant on the upper Todtalp slopes. What, then, is more natural than to suppose that the removed material was piled up in this position? Added to this, the difficulty of in any other way accounting for the lake and other features of the valley seemed to me conclusive.

Since then I have spent some months in studying the solid geology of the neighbourhood[2] and find that the results of this totally different line of inquiry are confirmatory of my former opinion. Thus the serpentine band undoubtedly occupies a constant position between certain rocks: it follows, that is, the strike of all the other formations. Its outcrop runs from between the Schiahorn and the Weissfluh down the Meierhoferthäli, and obliquely across by Wolfgang to Laret; it reappears on the east of the Lareterthal at Rüti, and crosses the Upper Landquart valley to Monbiel. The line of strike thus *excludes the whole of the Wolfgang-Drusatch barrier.* If that mass were composed of rock *in sitû* it would not be of serpentine, but of crystalline schists, limestone, and 'verrucano'; a continuation of the rocks of the Dörfliberg and

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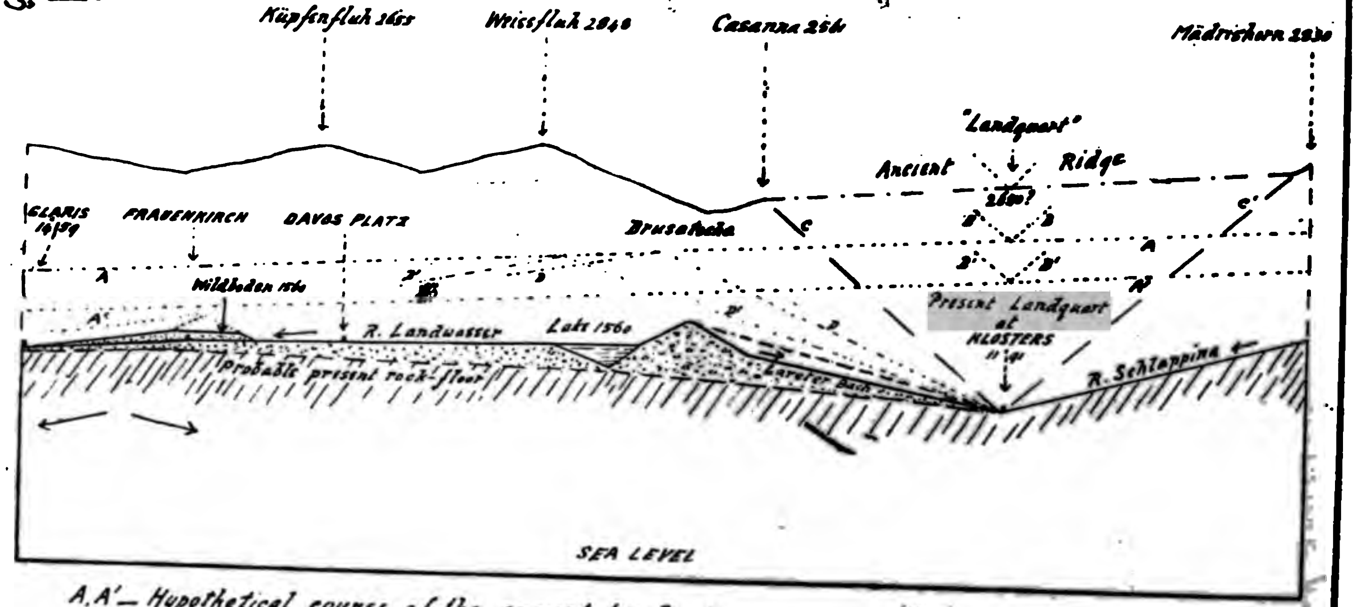
[1] I have been several times asked what date may be attributed to the former extension of the lake towards Frauenkirch, but I am not aware of any evidence on which conclusions can be based. The infilling of the old lake by detritus from the mountain sides and material brought down by the streams must have been going on since its earliest days, but it is probable that the final disappearance of standing water from parts of the Davos level is a very recent matter. The peat at the southern end seems modern, and above the Davos-Frauenkirch road the talus slopes contain a considerable quantity of peaty material near the surface. At the northern end, I am told that the Fluela discharged into the lake within the memory of those still living. It is said also that the Romans used the Fluela Pass as a route between the Prätigau and the Engadine, and the finding of Roman remains at Drusatcha suggests that they traversed the ridge at that point and passed round the shoulder of the Seehorn. This is not likely to have been their route if they could have crossed in the neighbourhood of Dorf. The name Wolfgang itself is said to represent the fact that the ridge formed the path of wolves from the eastern mountains, and this also seems to suggest that the foot of the Fluela valley was recently closed by the waters of the lake.

[2] The results of this survey are embodied in a paper read before the Geological Society on May 10th, 1899.

Fig: III.



A.A' — Hypothetical course of the ancient Landwasser.

B.B' — Stages in the cutting of the ancient ridge by the "Landquart"

C.C' — Present valley in position of the ancient ridge (Prättigau) of those which are seen on the east bank of the lake and which reappear north of the Mönchalpthal.

Returning now to the question of the course of the ancient Landwasser, I have endeavoured in Fig. 3 to represent in diagram its possible changes of position in relation to the Davos area.

If we imagine the Schlappinathal brought into line with the Laret-Landwasser valley, we obtain the present surface contour here shown. If we take a point near the source of the Schlappina and draw a line to the point near Glaris where the Landwasser now flows on solid rock, we may get an idea of what might have been the river-bed had the ancient Landwasser persisted to the present day. The lines A and A^1 drawn parallel to this at different heights may therefore represent its course at different remote periods. The cutting away of the western ridge may be represented by a succession of notches, B, B^1. On the supposition that this cutting was more rapid than the lowering of the river-bed there would have come a time when one of the notches reached the line A, A^1, and the Landwasser was consequently diverted into the Prätigau.

Subsequently the new river, the Landquart, widened its valley, till this gradually approximated to its present size, represented diagrammatically by C, C^1. At the same time the Schlappina on the north would be progressively lowering its level and nearing its present position. On the south it may be supposed that the stream representing the present Lareterbach would have lowered its bed through a succession of stages represented by D and D^1. The result of this would be the production of a watershed between it and the basin of the remaining Landwasser; there would be a ridge or divide just where, as a matter of fact, there is a deep lake. If the Wolfgang-Drusatch ridge were of solid rock *in sitû* it might at first sight be thought to satisfy the required conditions, but it is evident that its sudden drop of 350 metres on the south could not be attributed to erosion by the Landwasser. This brings us to the most important point of all: the striking fact that the bottom of the lake is *actually lower than the bed of the Landwasser at Glaris.*

It seems so impossible to reconcile this fact with any view but that which supposes a northerly slope of the rock-floor of the valley, that it appears scarcely necessary to pursue the subject further, and we may summarize the results of our whole inquiry somewhat as follows:—

(1) The theory of the former origin of the Landwasser in the Schlappinathal is not tenable if the Wolfgang-Drusatch ridge is solid.

(2) If this ridge is an accumulation of Glacial age the hypothesis may be still tenable, but only on the supposition that after the diversion of the Landwasser, the Fluela and Dischma were also turned northward and produced a rock-bed sloping toward Klosters from some watershed south of Davos.

(3) This second possibility does not, however, dispose of any of the difficulties attending the cutting of the Casanna-Mädrishorn

ridge, and under these circumstances it seems natural to suggest that after all the Fluela, Dischma, and Sertig, as well as the Schlappina, may have been original tributaries of the Landquart.

In this case there is no longer any difficulty in understanding the cutting of the mountain barrier just mentioned. The old river system would have had a much more usual character and would naturally take its place among similar systems in the surrounding mountains.[1] And lastly, if we accept this view, we are no longer at a loss to explain the anomalous physiographic features of the Davos valley, but, on the other hand, are in a position to offer a simple solution of its problems.

REVIEWS.

I.—Remarks on the Heliolitidæ. By G. Lindström. Kong. Svenska Vetenskaps-Akad. Handlingar, Bd. xxxii, No. 1. 4to; 140 pp., 12 plates. (Stockholm, 1899.)

UNDER the above modest title Professor Lindström has brought out a very important work dealing with the Heliolitidæ, a well-known family of Palæozoic Corals. At first intended as a review of the Swedish species merely, the scope of the work was afterwards enlarged, so that it now comprises a critical description of nearly all the known forms of this family, and it may be considered as a monograph of the group. The value of this work to the palæontologist depends not so much on the descriptions given of new and rare forms as on the very thorough and complete manner in which the author has investigated the structure of known species, by means of microscopic sections, and by this means establishing the detailed features by which one species may be distinguished from another. The characters assigned to the earlier known forms of this group were very frequently limited to those shown on the surface merely, and as these are in many instances very similar in species having a different internal structure, much confusion has consequently resulted. The author has spared no pains to ascertain the microscopic structural characters of the types of the known species, and these are represented with marvellous fidelity in the magnificent series of plates accompanying the memoir, and thereby much of the uncertainty respecting these species will be removed.

The earliest horizon on which the Heliolitidæ make their appearance is nearly at the summit of the Lower Silurian (Ordovician), none having been found below the Bala beds in England or the Wesenburg beds of Estland, whilst their highest limit is the lowest beds of the Upper Devonian. They have a very wide geographical distribution, as they are found in most countries where there are outcrops of Silurian and Devonian rocks. They are more especially abundant in Northern regions both of Europe and America, and the most prolific locality is the Isle of Gotland, from which place Lindström enumerates thirty species and varieties, out of a total of forty-six described in this memoir. Only eleven species occur in British rocks, and six or seven forms have been recognized in Australia.

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[1] Thus, the direction of the Fluela, Dischma, and Sertig is exactly the same as that of the eastern tributaries of the Inn, such as the Bernina and Chamuera. Again, their relationship to the present Lareterbach and the Landquart may be exactly paralleled north of the Rhätikon by the conditions existing between the Valzavenz *and Vergalda*, the Gargellenthal and the Montafun.

According to the author, there is very great difficulty in defining the limits of species in the Heliolitidæ, since even in the corallites of the same compound stock there is a considerable amount of variation in their dimensions, their distance from each other, and the amount of the cœnenchyma between them, but he finds that the shape and size of the septa, the nature of the cœnenchyma and dissepiments, and, subordinately, the mode of growth, are of more systematic value.

Lindström considers that the cœnenchyma is the most prominent general feature in the Heliolitidæ, and in this and the allied family of the Coccoseridæ four kinds of it are distinguished: (1) tubular, consisting of narrow polygonal tubes divided by regular horizontal tabulæ, as in *Heliolites*; (2) vesicular, of thin convex lamellæ, as in *Propora*, E. & H.; (3) bacular, of solid vertical rods or *baculi*, as shown in the Coccoseridæ; and (4) compact, composed of a dense, somewhat granular, homogeneous mass, showing longitudinal lines, the traces of filled-up tubuli. This occurs in *Pycnolithus*, gen. nov.

Considerable discussion has taken place with respect to the nature of the cœnenchyma in *Heliolites* and its allied genera, and the author gives an account of its early stages and manner of development. It is seen growing on the lower edge of the calicle of a primary or initial cornet-shaped polypierite, not more than 0·6 mm. in length and width, and may be developed either from one side of this initial form or all around a calicle, which, by rising as a tube above the parent cœnenchyma, introduces the intracalicinar gemmation, and thus for a time exists as a portion of a solitary individual. Lindström supports the view that the cœnenchyma of the Heliolitidæ is an endothecal structure, although no exterior theca for every single polypierite in a compound coral is developed, and, strictly considered, that it forms an integral part of every calicle in the compound coral.

Nicholson and Moseley, on the other hand, regarded the corallum in *Heliolites* as tenanted by two kinds of polypes: one kind, fully developed, inhabiting the septal calices (autopores); and the other, rudimentary form, occupying the surrounding tabulated tubes (siphonopores), which, therefore, were not cœnenchymal in character. It must be acknowledged that there are some facts tending to support the view, still held by some recent writers, that the siphonopores (cœnenchymal tubes) in *Heliolites* were occupied by zooids. Thus, for example, Nicholson[1] records the fact that in *Heliolites dubius*, Fr. Schmidt, a single siphonopore may sometimes be observed to be developed vertically and directly into an autopore. This observation has been confirmed by Gardeson, and Lindström also states that the narrow tubuli of the cœnenchyma in this species by-and-bye expand or widen and are changed into real calicles (p. 71). A similar metamorphosis of a cœnenchymal tube into a true calicle by a gradual increase in width and the development of septal spines, likewise occurs in *Heliolites hirsutus*, Linds., sp. nov.

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[1] Man. Pal., vol. i (1889), p. 337.

With regard to those genera in which the cœnenchyma is without tubuli, and consists of vesicular tissue with solid spines or rods, or of a compact sclerenchyma, the question of dimorphism can hardly arise.

In favourably preserved specimens, the structure of the thecal walls and the septa in the Heliolitidæ can be seen to consist of minute microscopic fibres radiating upwards and inwards from a median dark line (whitish by reflected light), the same as in most other corals. The septa in *Heliolites* are thin laminæ, sometimes with spiny margins; in the Plasmoporinæ they are reduced to a series of spines which spring from narrow longitudinal ridges within the calicle. Their degree of development varies much in the same stock, and in some instances they appear to be altogether wanting. There are twelve septa in the normal calicle, and this number is very constant throughout the group. There can be no doubt of the true nature of the septa in the Heliolitidæ, and they are entirely distinct in character from the pseudosepta in *Heliopora*, with which they have wrongly been compared. Three modes of increase have been observed: by cœnenchymal, intracalicinal, and epithecal or cœnothecal gemmation. As a general feature, Lindström has noticed that some of the earlier species are characterized by closely placed calicles and slight development of cœnenchyma, which may perhaps indicate a descent from ancestors without cœnenchyma. In Lower Silurian (Ordovician) strata the predominant types belong to the Plasmoporinæ and the allied Coccoseridæ (these latter are confined mainly to the lower horizon); whilst the Heliolitinæ proper flourished principally in the Upper Silurian.

As the chief distinguishing features of the Heliolitidæ and the allied Coccoseridæ, the author states that the individual polypierites are composed of an interior area enclosed within an inner theca, with twelve regular septa, and of an exterior area without any separating wall for each polypierite, and forming a differently shaped cœnenchyma.

Lindström subdivides the Heliolitidæ into three tribes, mainly according to the nature of the cœnenchyma: (1) Heliolitinidæ, with lamellar septa and cœnenchyma of polygonal tubes; (2) Plasmoporinæ, theca thick, cœnenchyma vesicular; and (3) Pycnolithinæ, with dense, compact, granular cœnenchyma.

The subfamily Coccoseridæ is characterized by short thick septa, the central area of the calicle is filled with columnar bacilli which project as papillæ on its floor, the cœnenchyma is bacular, tubes when present are narrow with a few tabulæ. In this sub-group the following three genera are included: *Coccoseris*, Eichwald, *Protaræa*, *E. & H.*, and *Acantholithus*, Linds., gen. nov.

In the tribe Heliolitinæ are comprised three genera: *Heliolites*, Dana, with a cœnenchyma of tubes of one kind and size; *Cosmiolithus*, gen. nov., in which two different kinds are present; and *Proheliolites*, Kiær, with slightly developed cœnenchyma, with gemmation from single tubes. The septal spines are bent downwards.

The predominant genus, not only of the tribe, but of the whole family, is *Heliolites*, Dana, and in this genus eleven species and varieties are described, six of these being new forms. The very thorough microscopic revision to which the various species of the genus have been subjected by the author has involved, as might have been anticipated, the suppression of some reputed species and the transposition of others, and it may be that some of these changes will not be accepted without protest. As an instance of a needful alteration may be mentioned *Heliolites* (*Fistulipora*) *decipiens*, McCoy, sp., hitherto regarded, even by Lindström, as a species, but now proved to be only a phase or growth modification of *H. interstinctus*, L., and thus merely a variety of this latter. In the same specimen there may be found some calicles with fully developed septa as in *H. interstinctus*, others without a trace of septa, as in *H. decipiens*, and yet other calicles with the septa unequally developed.

As incidental to the presumed affinity between the Heliolitidæ and such forms as *Monticulipora*, *Callopora*, and *Fistulipora*, now very generally regarded as Polyzoa, the author enumerates seven chief differences in the structure of these groups, of which the most important appears to be the dissimilarity of the intimate microscopical structures composing their walls.

In the tribe Plasmoporinæ are included *Plasmopora*, M. Edw. and Haime, *Propora*, M. E. & H., *Camptolithus*, gen. nov., distinguished by having the same kind of vesicular tissue in the calicles as in the cœnenchyma; and *Diploëpora*, Quenstedt, in which there are two kinds of cœnenchyma—an inner of vesicular character and an outer of closely arranged parallel rods. The only species of this genus is *D. Grayi*, M. E. & H., sp. The genus *Lyellia*, M. E. & H., is not retained, on the ground of its similarity to *Propora*.

As a special feature of *Plasmopora*, it is pointed out that the septa extend beyond the calicular theca, and their ends are united together by a curved lamina so as to form a stelliform area or aureola, enclosing longitudinal compartments around the calicle. Thirteen species are placed in the genus, ten of which are new forms. In *Propora* the calicles are exsert, the cœnenchyma entirely vesicular, and there is no aureola. Nine species and varieties, including six new forms, are described. The genus *Pinacopora*, Nichol. & Eth., is considered to be a synonym of *Propora*.

The only genus of the Pycnolithinæ tribe is *Pycnolithus*, gen. nov., in which the common type of calicle is accompanied by a dense, compact cœnenchyma, without any structure, but with a surface ornamented by shallow elongate grooves and pits.

We are unwilling to conclude this notice without again repeating our warm appreciation of the able manner in which the subject has been treated by Professor Lindström, and our admiration of the results of his long-continued efforts in investigating the minute characters of Palæozoic corals. The present memoir is a worthy addition to the numerous valuable contributions to palæontology which the author has made during his long career. Palæontologists of all countries will cordially echo the author's thanks to the Royal Swedish Academy of Sciences for defraying the expenses of publishing such an important work, and more particularly the English-speaking ones for its appearance in this language. But we have often felt in turning over the pages, what a great pity it was that the proofs had not been revised by some one whose knowledge of the mother tongue would have eliminated those subtle mistakes inevitable to those "not to the manner born." G. J. H.

II.—The Geology of the Country around Carlisle. By T. V. Holmes, F.G.S. 8vo; pp. iv, 64. (London: printed for H.M. Stationery Office, 1899. Price 1s. 3d.)

A GOOD many years have elapsed since Mr. Holmes was engaged on the Geological Survey of the country around Carlisle, and there has been a regrettable delay in issuing the present Memoir. This has to some extent arisen (as the Director-General points out) from the difficulty in interpreting the structure and relations of the Permian and Triassic rocks of the district. The country in question is almost wholly covered with Drift, and it was therefore by no means easy to piece together the evidence obtained from a few boreholes and from the cliffs bordering streams and rivers, and to produce a map showing the solid structure of the ground without the mantle of boulder-clay and gravel. The conclusions at which Mr. Holmes arrived were not those to which Mr. Aveline and the late Sir Andrew Ramsay could agree; and in consequence the 'solid' edition of the map, when published, did not in many important respects coincide with the views of Mr. Holmes. In the present Memoir he very clearly states the evidence obtained; and it is interesting to read (in the Director-General's preface) that "In the Carlisle region, as in Devonshire, no definite plane of separation can be satisfactorily traced between the Permian and the Triassic formations." These red rocks include the St. Bees Sandstone Gypseous Shales, Kirklinton Sandstone, and Stanwix Shales. No traces of Rhætic beds have been discovered, but there is an interesting outlier of Lower Lias. The various superficial deposits are described, and some account is given of the Solway Moss, and of its bursting in 1771.

III.—The Geology of the Borders of the Wash: including Boston and Hunstanton. By W. Whitaker, F.R.S., and A. J. Jukes-Browne, F.G.S. 8vo; pp. vii, 146. (London: printed for H.M. Stationery Office, 1899. Price 3s.)

THIS Memoir, which is an Explanation of Sheet 69 of the (old series) Geological Survey Map, contains an account of the geology of portions of the Fenland in Lincolnshire and Norfolk, and of the more interesting region of Lower Greensand, Gault, Red

Chalk, and White Chalk in West Norfolk. So far as Norfolk is concerned this Memoir completes the description of that county by the Geological Survey, and it contains a Bibliography supplementary to that published in "The Geology of the Country around Norwich" (1881). In the work before us we have the benefit of some recent observations on the Lower Greensand, made by Mr. G. W. Lamplugh, who has added much to the knowledge gained by his colleagues and by geologists who preceded them. He divides the formations into—

	Approximate Correlations.
Carstone	= Folkestone, Sandgate, and Hythe Beds.
Snettisham Beds	= Tealby Limestone.
Sandringham Sands	= Tealby Clay.

It is interesting to note that Mr. Lamplugh believes that the Sandringham Sands, as a whole, are newer than the Spilsby Sandstone.

Much of the information with regard to the Gault and Red Chalk, and also of the Lower and Middle Chalk, has been previously published by Messrs. Jukes-Browne and William Hill. It is, however, useful to have the information brought together in a handy form, especially in connection with the classic regions of Hunstanton. The detailed information on the Glacial Drifts and superficial deposits contains much new matter, and there are appended the records of numerous well-sections in Norfolk and Lincolnshire.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 22, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Relations of the Chalk and Drift in Möen and Rügen." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and the Rev. Edwin Hill, M.A., F.G.S.

These two islands are separated in a north-westerly to south-easterly direction by about 35 miles of sea. They both exhibit at many spots the Chalk and Drift, in relations which are peculiar and abnormal. Some geologists maintain that the glacial beds have been included in the Chalk by a series of acute folds; others, that they have been dropped down by a series of faults; others, again, explain the relationship as the result of ice-action. Simple faulting appears to be insufficient, while it is a circumstance not easily explained by earth-movement or ice-action that the axes of the folds in the Chalk strike roughly east-north-east to west-south-west in Möen and north and south in Rügen.

The authors then describe a series of sections in Möen which lead them to the following conclusions:—

(*a*) The Chalk dominates greatly over the Clay, the latter being often merely a local phenomenon.

(*b*) The Chalk is stained brown, and the Clay streaked with chalk for a few inches from the junction.

(*c*) The Clay is often a mere facing to the Chalk, or occupies semi-cylindrical or wedge-shaped cavities, which sometimes seem to terminate above sea-level.

(*d*) The Clay seems often associated with superficial ravines, which are probably never much prolonged below the sea-level. The Chalk is strongly folded, but rarely, if ever faulted, and there is no evidence to connect the intercalations of Drift with faults.

Numerous sections in Rügen are then described, which (though there are differences in detail) present a general resemblance to those in Möen, and as a rule have no resemblance to those near Cromer. After discussing and rejecting the hypotheses (faulting or folding and the thrust of an ice-sheet) which at present apparently occupy the field, the authors point out that any satisfactory theory must be in accordance with the following facts:—(1) The tripartite and generally orderly arrangement of the Drift (Rügen only); (2) the frequent unconformity of the Drift with the Chalk; (3) the occurrence of valleys or clefts in the Chalk; and (4) the variations in inclination of the Drift-beds, without the loss of their general evenness of bedding. If, at the beginning of the Glacial period, the surfaces of the islands had assumed nearly their present outlines, they may have become permanently covered with snow without the formation of glaciers. Drift might have been deposited on this frozen surface—first clay, next sand, and then another clay. When the climate ameliorated, the more or less frozen Drift would settle down, as the snow underneath it melted, warping and twisting over the crags and projections of the Chalk surface, moulding itself into the depressions, and dropping into the pipe-like hollows, as the snow and ice below gave way.

The authors abstain from discussing the physical conditions under which the Drifts accumulated.

2. "A Critical Junction in the County of Tyrone." By Professor Grenville A. J. Cole, F.G.S.

The investigations of the author have led him to the conclusion that the granite of Eastern Tyrone is identical with that of Slieve Gallion. In the Memoir of the Geological Survey it is shown that the Lower Carboniferous beds near Moneymore are full of fragments of the former granite, while it is considered that the Devonian grits at Aghnaoreggan are "vitrified and turned into quartzite" at the junction. The 'quartzite' appears to be fine-grained yellowish granite, while the Devonian rocks exposed by excavation at the junction are mainly made up of large and small fragments derived from the granite. The granite is therefore of pre-Devonian age, and may be linked with those of Cavan and other parts of Ireland which are connected with the 'Caledonian' epoch of mountain-building; but it is possibly even pre-Ordovician.

II.—April 12, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Mr. A. M. Davies, in exhibiting a specimen of glauconitic limestone from the Kimeridge Clay, said that it might easily be taken for Upper Greensand. It came from a road-cutting near Wombwell's Farm, Chilton (Bucks), about 40 feet below the top of the Hartwell Clay, and therefore evidently from the true Kimeridgian. The outcrop of the stone gives rise to a slight but distinct feature, traceable for about ½ mile along the hillside. There are traces of fossils in the stone, but an impression of a *biplex* Ammonite was alone recognizable. No similar bed had been previously recorded from the English Kimeridgian.

The following communications were read:—

1. "Fossils in the University Museum, Oxford: I. Silurian Echinoidea and Ophiuroidea." By Prof. W. J. Sollas, M.A., LL.D., D.Sc., F.R.S.

Attention is called to the correlation of structure and function in the locomotive organs of Asterids, Ophiurids, and Echinids. In the case of the two latter, movement depends on tension directed along the tube-feet. In starfishes this tension is met by the disposition of the ambulacral ossicles in the form of an arch: in urchins by a continuous tessellation of the surface, which would only be weakened by arch-like interruptions. If, however, urchins have been evolved from an Asterid stem, they may have originally possessed arch-like ambulacral grooves, and the present plates of the ambulacra may have been subsequently acquired. In *Palæodiscus ferox* of the Lower Ludlow, Leintwardine, which by the structure of the buccal armature is definitely shown to have been an Echinid, the ambulacra possess just such characters as theory anticipates: an inner arch of poriferous ambulacral plates, homologous with those of a starfish, is closed externally by a series of paired plates, which represent the ambulacral series of an urchin.

The undoubted Asteroid affinities of the urchin lead to an attempt to find homologies for the elements of 'Aristotle's Lantern': the pyramids are regarded as equivalent to the first pair of adambulacral plates, the epiphyses to the corresponding pair of ambulacral plates of the Echinoid series, and the teeth are compared to the Asteroid odontophore, which has acquired a persistent root.

A new genus assigned to the Echinida is characterized by the excessively numerous minute plates which form the interambulacra. Reference is made to *Echinocystis pomum*, Wyv. Thomson; and to a species of *Protocidaris*, Whidborne, from Lower Ludlow beds, which seems to be identical with the type-species found in Devonian rocks.

The results are given of a re-examination of the unique specimen on which Dr. H. Woodward founded the genus *Eucladia*. The author agrees with Dr. Woodward in regarding the exposed surface of this fossil as ventral; it bears the buccal armature and madreporite, and gives origin to the arms. On slicing two of the arms, no plates were exposed which it was possible to certainly identify with vertebral ossicles. Some hollow casts, from the Lower Ludlow of Leintwardine, which have hitherto been regarded as too problematical for determination, are shown to represent an organism closely allied to *Eucladia*, and are provisionally referred to that genus. The number of arms in this new species is less than in the original (*E. Johnsoni*), and they are more nearly equal in size. A new genus, closely allied to *Eucladia*, is founded on a small, well-preserved specimen from the Wenlock Limestone of Croft Farm. In this the pairs of arms or each paired series are only two in number, while in the new species of *Eucladia* at least four, and in *E. Johnsoni* as many as seven, are present. *Eucladia* and the new genus are regarded as aberrant Ophiurids, and are placed in a new order as a group of the same value as the Euryalæ. They are defined as Ophiurida possessing paired series of arms, covered externally by imbricating plates, but devoid of ambulacral ossicles. The buccal armature is abnormal.

2. "Note on the Occurrence of Sponge-spicules in the Carboniferous Limestone of Derbyshire." By Prof. W. J. Sollas, M.A., LL.D., D.Sc., F.R.S.

Remains of sponge-spicules are fairly abundant in a rock-slice taken from a specimen obtained by Mr. H. H. Arnold-Bemrose from Tissington cutting. They present themselves as sections through long cylindrical rods, but the terminations are obscure and indefinite, and the form cannot be referred with certainty to any recognized order of Sponges. The spicules were doubtless originally siliceous, but they are now completely transformed into carbonate of lime. Rhombohedra of calcite appear to have completed their growth as readily within the spicule as outside it, and the final result of the corrosion is to entirely replace the opal of the spicule by a congeries of minute crystals of calcite. As the crystals may have begun their growth outside the spicule, the latter rarely preserves its characteristic regular outlines. The crystals being frequently bounded by impurities of the limestone, the spicules are often as clearly defined as corresponding structures in the Chalk.

3. "On Spinel and Forsterite from the Glenelg Limestone." By C. T. Clough, Esq., M.A., F.G.S., and Dr. W. Pollard, M.A., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The paper opens with an account of previous literature on the subject of minerals in the Glenelg limestone. Neither forsterite nor true spinel has been previously recorded from the limestone or from Scotland at all. The three or four bands of limestone which make their appearance on Sheets 123 and 127 of the 6-inch survey of Ross-shire are probably the same bed repeated by isoclinal folds. The banded gneisses, schists, and eclogites among which the *limestones* occur are separated from the sheared and inverted Torridonian rocks on the west-north-west by flaggy granulitic quartzite and siliceous mylonite, the latter being next to the Torridonian rocks and lying along the line of a great post-Cambrian thrust, traceable from Oronsay to near the Point of Sleat. On the eastern side of the mylonite all the rocks of sedimentary aspect are greatly altered, and the gneisses and schists associated with the limestone resemble parts of the Lewisian gneiss. The quartzite-series is repeatedly folded with the gneissose series; but although the precise relationship of the two has not been made out, rocks of different characters lie next to the quartzite in different places, while the alteration-products which characterize the limestone are found in contact with the quartzite at one or two spots. In the limestone, pieces of diopside and a serpentine-like mineral are so abundant that they may equal the rest of the rock in quantity. The mass of the limestone is but little affected by movement, thus offering a strong contrast to the Loch Maree limestone. The forsterite and spinel are in part associated together in lumps, from which they were separated by means of heavy solutions for analysis. The spinel in hand-specimens is of an almost opaque blue colour, and some examples show small crystal-faces. That seen in microscopic slides is shapeless and colourless, except that the blue portions appear brown by transmitted light. Analyses of the two minerals are given at the close of the paper; and it is pointed out that the spinel is like that of Åker in colour and mode of occurrence.

III.—April 26, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On Limestone-Knolls in the Craven District of Yorkshire and elsewhere." By J. E. Marr, Esq., M.A., F.R.S., F.G.S.

The author begins with a general account of the district, partly founded on the published work of Mr. R. H. Tiddeman, but substantiated by his own observations. The Lower Carboniferous rocks north of the Craven Fault-system differ in character and thickness from those on the south; they exhibit little disturbance on the north, but on the south they are thrown into a series of folds, while it is also on this side that the knobs of limestone called knoll-reefs by Mr. Tiddeman occur. In order to illustrate the nature of the disturbances south of the Craven Faults, the folds of Draughton Quarry are described in detail. In addition to the anticlines and syncline usually figured, there occurs, on the north side of the quarry, an overfolded anticline with a faulted core. One of the calcareous bands is really a limestone-breccia, which appears to have been broken by earth-movement before the rocks were folded. The top and base of the breccia and of other hard bands, together with the joint-faces, are traversed by slickensides which were horizontal before the folding. Microscopic examination of the limestones shows that they exhibit various stages in crushing with development of a ribboned structure due to movement, while the matrix in other varieties has become crystalline, as though under relief from pressure.

The limestone is squeezed into the softer shale-bands, and a thin limestone-seam which occurs in one of the principal shale-beds is frequently repeated by faulting, and in one case is heaped up by repetition to form a miniature knoll, which possesses many of the characters of the larger knolls.

The prominent features of the knolls are the crystalline character of the limestone, the horizontality of bedding in the interior of the knolls the general parallelism of the bedding of the exterior to the contour of the knolls, and the obscurity of the bedding. Fossils, when present, are usually very perfectly preserved and undistorted; breccias are frequently found in the shales bordering the knolls and, much less commonly, in the limestone of a knoll itself. Evidence of movement in the knolls is seen in the lenticular character of the beds of limestone, in visible folded structures, the termination of lenticular beds in hooks against a divisional plane, and in the shales by the presence of a structure undistinguishable from cleavage. Dolomitized and silicified limestones are frequently associated with the knolls, and the perfection of the quartz-crystals in certain examples of the latter variety of rock suggests crystallization during relief of pressure. The breccias belong to three main types:—(1) Fragments of limestone in a matrix of similar material; (2) large nodules of black limestone enwrapped in shales; (3) various limestone fragments in a fine calcareous paste. Examples of each type are described, and each is explained as resulting from some form of earth-movement. Breccias of similar types are found to be produced out of grit fragments, and in places the grits are found to be piled together by faulting, so as to produce knolls which somewhat resemble those in the limestone.

A comparison of the deposits in both sides of the faults enables the author to suggest the following correlation of the beds:—

South Side.	North Side.
Millstone Grit.	Millstone Grit.
Bowland Shales.	Shales above Upper Scar Limestone.
Pendleside Limestone.	Upper Scar Limestone.
Shales with limestone.	Yoredale Shales with limestone.
Clitheroe Limestone.	Lower Scar Limestone.

The disparity in thickness of the limestone on the two sides will not be so marked, if the explanation of knolls given in the paper be correct. Dealing with the nature of the movements, the writer argues that the Middle Craven Fault is an overthrust from the north, and that the Limestone Series has undergone differential movements with respect to the hard Lower Palæozoic rocks beneath and the massive Millstone Grit above. The limestones have been squeezed out from under the synclines, and they have accumulated under the anticlines where the pressure was relieved. In conclusion, a number of examples of knolls are cited from other localities which show similar features, such as the limestones of Keisley, Millom, and near Dalton-in-Furness, some of the Devonian limestones near Torquay, the *Leptæna*-limestone of Dalecarlia, and the Devonian limestone of Koñeprus in Bohemia.

2. "The Limestone-Knolls below Thorpe Fell, between Skipton and Grassington in Craven." By J. R. Dakyns, Esq., M.A. (Communicated by the President.)

A band of limestone runs from Cracoe towards the north-east, folded in an anticline and dipping under shales. In several places the top of the limestone is brecciated and the overlying (Bowland) shale contains fragments of limestone. The limestone forms five abrupt conspicuous hills. The rocks in most of these hills are not bedded, and where they are bedded the dip is confusing; both in exposures outside of these and in adits inside, the limestone in some cases is amorphous and without any sign of bedding. When Mr. Tiddeman propounded his view that the limestone was originally formed in the shape of knolls or mounds, the author accepted his opinion for these particular hills. There is evidence that the surface of limestone underneath the shales is uneven. On Simon's Seat, a Millstone-Grit fell, there are swallow-holes showing that limestone is not far below; while below Thorpe Fell at least 450 feet of shales overlie the limestone. The author considers the absence of bedding in the limestone to be a very important feature; for in the country south of the North Craven Fault, though the rock is excessively contorted, its bedding has not been destroyed.

3. "On three Species of Lamellibranchs from the Carboniferous Rocks of Great Britain." By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

The first part of this paper describes a new species of *Anthracomya* which occurs in the North Staffordshire and Manchester Coal-fields at horizons higher than that characterized by *A. Phillipsi.* The fossil is found at Etruria, Bradwell, Stoke-on-Trent, and Fallowfield. It appears to indicate a special zone of shales and *Spirorbis*-limestone about 300 feet below the Penkhull Sandstone, and to be the only molluscan form known from the zone.

A new species of *Carbonicola* is next described, partly from specimens previously supposed to be a gasteropod, a brachiopod, or even a crustacean, and partly from better-preserved specimens obtained from calcareous bands about 10 yards above the Bassey Mine Ironstone in North Staffordshire. It appears to be the latest species of this genus known, and to occur in higher beds than any other species.

Lastly, a new species of *Ctenodonta* from Penton Linns (Dumfriesshire) is described. It occurs in a marine shale below the highest limestone of the locality, in beds referred to the horizon of the Hurlet Limestone by the officers of the Geological Survey. The bed contains gasteropods, crinoids, cephalopods, etc., with *Productus giganteus.* The species has some resemblance to *C. Halli,* Barrois, found in Spain.

CORRESPONDENCE.

THE RIVER OF THE BALTIC.

SIR,—Mr. Hudleston's paper "On the Eastern Margin of the North Atlantic Basin" is so full of important facts, and so carefully thought out, that I am almost afraid to criticize even a minor detail. But in rejecting, with a note of sarcasm, the suggestion that the deep channel which runs round the southern lobe of Norway may at one time have carried off the drainage of the Baltic area (then land), because the soundings go down to 440 fathoms in the Skagerak, off Arendal, and are not more than 160 fathoms in one part west of the Naze, has he not overlooked some possibilities? Obviously "the river of the Baltic must have had some difficulty in draining towards the Atlantic under these circumstances." But have "these circumstances" always existed; in other words, are we entitled to assume (as he has tacitly done) that the present slope of the bed is the original one? Apart from that, if the channel is not a portion of an old river system—an ancient valley—what is it? If it be made by crust movements, the shape is singular, and we may fairly ask, if called upon to put away our belief, for something better as a substitute. Or would Mr. Hudleston allow it to be a valley, but draining southward? If so, what became of it, and is there any evidence of a general drainage in that direction as the Pliocene period was nearing its end? If ever the bed of the Baltic became dry land its drainage would have to go somewhere, and one or two North German rivers also would have to be accommodated. I am aware that the second set of movements in the Alpine chain greatly modified the drainage system of Europe, but I doubt whether there have been any revolutionary changes since that epoch. Assuming then, as I suppose we are justified in doing, this channel to be a Pre-Glacial feature, are we warranted in also assuming its bed to have retained its original slope and contours without any alteration? The present form is peculiar and suggestive. In Bohus Bay, almost west of Lake Wettern, is a limited area in which the soundings reach 355 fathoms (a larger one being below the 250-fathom contour), and in one place, slightly north of the latitude of Christianssand, we find 430 fathoms. The channel round the southern end of Norway (the deeper part being on that side) seems to vary from 250 to 300 fathoms. Then (north-west of the Naze) it rises for a little while to from 150 to 175 fathoms, and afterwards, till about opposite to the Sogne Fjord, it barely reaches 200 fathoms. But then it steepens steadily till off the Romsdal Fjord, where it returns to 400 fathoms. Doubtless this variation in depth is remarkable, but we must remember that if the channel be Pre-Glacial much débris must have been 'dumped' irregularly on its floor, even though it proved a barrier to the westward march of the Scandinavian ice-sheet. We must also remember that the Post-Glacial movements of recovery in Norway have been very far from uniform. There is, however, another remarkable fact which appears to have escaped my *friend's notice*. This basin of the Skagerak lies on the westward prolongation of a belt which, beginning with the Gulf of Finland, runs across Sweden in a direction slightly south of west; thus including the fjord-pierced coast about Stockholm and the Lakes Malar, Wettern, and Wenern—a belt which is suggestive of special depression. May not this Skagerak basin be only a drowned lake? It is no doubt much deeper than either Wettern or Wenern, for the one is about 50 fathoms at most, and the other is shallower, about 20 fathoms; but making some allowance for débris, not a deeper basin than the Lake of Geneva. Mr. Hudleston seems to admit that the deeper part of St. George's Channel may be a drowned river-valley, but the slope of this, if I remember rightly, exhibits some anomalies, which, though on a minor scale, seem best explained by a certain amount of differential movement in the earth's crust. That such movements have occurred comparatively late in geological times, would, I suppose, now be generally admitted.

T. G. BONNEY.

OBITUARY.

PROFESSOR SIR FREDERICK McCOY, K.C.M.G., M.A., D.Sc. (CANTAB), F.R.S., F.G.S.

BORN 1823. DIED MAY 16, 1899.

IT is with deep regret we have to record the loss of another accomplished Naturalist, Geologist, and Palæontologist, belonging really to the first half of the present century, but who has survived almost to its close. The cable announcement appeared in the London daily newspapers of May 18, of the decease of Sir Frederick McCoy, Professor of Natural Science in the University of Melbourne, Australia, in his 76th year. His last communication to the GEOLOGICAL MAGAZINE appeared in the May Number, p. 193. Professor McCoy was the acknowledged chief of the scientific world of Australasia, where his name and fame will be perpetuated by the splendid Museum of Natural History and Geology in Melbourne, of which he was the founder and lifelong presiding genius.

Frederick McCoy was the son of Dr. Simon McCoy, M.D., of Dublin, and was born in that city in the year 1823. He was educated originally for the medical profession, and attended lectures, hospital practice, etc., in Dublin and also in Cambridge; but while yet too young to be admitted to the profession he devoted himself assiduously to the study of all branches of Natural Science, classifying the collections of the Geological and Royal Societies of Dublin, with the object of applying recent Zoology to Palæontology as the basis of stratigraphical geology. About this time he accepted the offer of Sir Richard Griffith to make the palæontological investigations required for the Geological Map of Ireland for the Boundary Survey, publishing the results in a large quarto volume in 1844, with numerous plates including figures of several hundred new species of fossils, entitled "Synopsis of the Carboniferous Limestone Fossils of Ireland," and a smaller work in 1846, "Synopsis of the Silurian Fossils of Ireland." He was then invited by Colonel Sir Henry

James, R.E., and Sir Henry de la Beche to join the Imperial Survey of Ireland, just then commenced, and after completing the maps of the districts surveyed by him in the field, he was appointed by Sir Robert Peel's Government as one of the first Professors of the Queen's University in Ireland, the Chair of Geology and Mineralogy in the Northern College being assigned to him, where he lectured in the Queen's College, Belfast, and examined students in Dublin. About this time he undertook, in conjunction with Professor Sedgwick, the large work on British Palæozoic Rocks and Fossils, based on the materials in the Woodwardian Museum at Cambridge, and to make the critical examination of the great series of fossils of the older formations brought together by Sedgwick; the results of these labours being deemed worthy of the compliment of publication by the Syndics of the University Press of Cambridge, in a large quarto volume, with numerous plates of new fossils from the Carboniferous, Devonian, Silurian, and Cambrian formations, which was issued in 1852, as the second volume of a proposed joint work (but the first volume, which was to have comprised the Rocks, by Professor Sedgwick, was never published), entitled "British Palæozoic Rocks and Fossils," by Professors Sedgwick and McCoy.

Professor McCoy was then appointed by Sir J. Herschel and the Astronomer Royal, Sir G. B. Airy, as the first Professor of Natural Science in the University of Melbourne, where, having taken part in the formation of the University, he lectured on Chemistry, Mineralogy, Botany, Comparative Anatomy, Zoology, Geology, and Palæontology, for upwards of thirty years. He also established the National Museum of Natural History and Geology in Melbourne, of which he was Director to the last, raising it to a distinguished position, not only by the extent of the collections but also by the perfection of their classification. He was Chairman of the first Royal Commission on the Gold-Fields of Victoria; Member from the first of the Royal Commission on Technological Instruction; Member of the Royal Commission on Education; Member of the various Royal Commissions for International and Intercolonial Exhibitions for the Colony of Victoria. He was appointed Government Palæontologist at an early stage of the Geological Survey, determining the ages of the various tracts published on the Maps.[1] For over thirty years he prepared, and continued to publish in decades at short intervals, two works for the Government of Victoria, one entitled "Prodromus of the Zoology of Victoria," with coloured figures from the life, and another, "Prodromus of Palæontology of Victoria." He was a Justice of the Peace for Victoria. He was elected a Fellow of the Royal Society of London in 1880, and was created one of the first Doctors in Science, *honoris causâ*, by the University of Cambridge. The Royal University of Ireland also conferred on him their highest degree in Arts and Sciences. He was created a Knight or Chevalier of the Royal Order of the Crown of Italy by King Victor Emmanuel, and has been offered similar distinctions by other foreign sovereigns in recognition of his scientific work. In 1886 he received the decoration of C.M.G. from Her Majesty, and was created a Knight Commander of the Order in 1891. He has also received the Emperor of Austria's great gold medal for Arts and Sciences, the Murchison Medal from the Geological Society of London, and other similar distinctions. He was elected one of the few (only thirty subjects of the Queen being eligible) Honorary Members of the Philosophical Society. He was an Honorary active Member of the Imperial Society of Naturalists of Moscow, and Honorary Fellow and Member of many other British and Foreign scientific bodies.[1]

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[1] *See the* Life of A. R. C. Selwyn, C.B., F.R.S., in Geol. Mag., *February, 1899, pp. 49–56.*

The following is a list of the titles of Professor Sir Frederick McCoy's separate and smaller contributions to Natural Science; his larger works have already been mentioned in this Memoir:—

1. "Remarks on Mr. Eyton's Arrangement of the Gulls": Mag. Nat. Hist., vol. ii (1838), pp. 487–490.
2. "On a new Genus of Entomostraca (*Entomoconchus Scouleri*)": Dublin Geol. Soc. Journ., vol. ii (1839), pp. 91–94.
3. "On some new or rare Fish (*Trigla Blochii, Cottus Grœnlandicus, Thynnus Pelamys*) occurring on the Coast of Ireland": Ann. Nat. Hist., vol. vi (1841), pp. 402–8.
4. "Contributions to the Fauna of Ireland (*Vespertilio Nattereri, Tringa rufescens, Sterna leucoptera, Syrinx Forbesii, S. tenuicinctus*)": ibid., vol. xv (1845), pp. 270–4.
5. "Note on the Irish Species of Cephaloptera (Pterocephala)": ibid., vol. xix (1847), pp. 176–8.
6. "On the Fossil Botany and Zoology of the Rocks associated with the Coal of Australia": ibid., vol. xx (1847), pp. 145–157, 226–236, 298–312.
7. "On the Plants of the New South Wales and Van Diemen's Land Coalfields": Brit. Assoc. Rep., 1847, pt. ii, pp. 64, 65.
8. "On some new Fossil Fish of the Carboniferous Period": Ann. Nat. Hist., vol. ii (1848), pp. 1–10, 115–133.
9. "Reply to Sir Philip Egerton's Letter on the Placodermi": ibid., vol. ii (1848), pp. 277–280.
10. "On some new Ichthyolites from the Scotch Old Red Sandstone": ibid., vol. ii (1848), pp. 297–312.
11. "On some new Mesozoic Radiata": ibid., vol. ii (1848), pp. 397–420.
12. "On some new Genera and Species of Palæozoic Corals and Foraminifera": ibid., vol. iii (1849), pp. 1–20, 119–136.
13. "Reply to Sir Philip Egerton's Letter on the Tail of *Diplopterus*": ibid., vol. iii (1849), pp. 139–140.
14. "Reply to Professor Owen's Letter on the Ganoine of some Fish Teeth": ibid., vol. iii (1849), pp. 140–1.
15. "On some new Palæozoic Echinodermata (*Codaster*, n.g., *Perischodomus*, n.g.)": ibid., vol. iii (1849), pp. 244–254.
16. "On the Classification of some British Fossil Crustacea, with Notices of New Forms in the University Collection at Cambridge": ibid., vol. iv (1849), pp. 161–179, 330–5, 392–414.
17. "On some new Genera and Species of Silurian Radiata in the Collection of the University of Cambridge": ibid., vol. vi (1850), pp. 270–290.
18. "Descriptions of three new Devonian Zoophytes—*Stromatopora* (*Caunopora*) *verticillata, Alveolites vermicularis, Strephodes gracilis*": ibid., vol. vi (1850), pp. 377–8.
19. "On some new Silurian Radiata (*Strephodes pseudoceratites. St. trochiformis, Cœnites strigatus, Palæophora subtilis, Retepora Hisingeri*)": ibid., vol. vi (1850), pp. 474–7.
20. "On some new Silurian Mollusca (*Poterioceras ellipticum, Phragmoceras*

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[1] Chiefly derived from "Men and Women of the Time," 14th edition, 1895.

intermedium, Holopella gracilior, Cucullella, n.g., *Anodontopsis angustifrons*, etc.)": ibid., vol. vii (1851), pp. 45–63.

21. "Descriptions of some new Mountain Limestone Fossils (nov. gen. *Streblopteria, Aviculopecten*)": ibid., vol. vii (1851), pp. 167–175.

22. "On some new Protozoic Annulata (*Crossopodia lata, C. Scotica, Myrianites tenuis, Trachyderma lævis*)": ibid., vol. vii (1851), pp. 394–6.

23. "On some new Cambro-Silurian Fossils": ibid., vol. viii (1851), pp. 387–409.

24. "On some new Devonian Fossils (*Steganodictyum*, n.g., etc.)": ibid., vol. viii (1851), pp. 481–9.

25. "Contributions to British Palæontology: Some new Lower Palæozoic Mollusca": ibid., vol. x (1852), pp. 189–195.

26. "Contributions to British Palæontology: On some new Brachiopoda from the Carboniferous Limestone": ibid., vol. x (1852), pp. 421–9.

27. "On the Mode of Succession of the Teeth in *Cochliodus*": Brit. Assoc. Rep., 1852, pt. ii, p. 55.

28. "On some new Carboniferous Limestone Fossils": Ann. Nat. Hist., vol. xi (1853), pp. 188–197.

29. "On the supposed Fish-remains of the Silurian System": Geol. Soc. Journ., vol. ix (1853), pp. 12–15.

30. "On some new Cretaceous Crustacea": Ann. Nat. Hist., vol. xiv (1854), pp. 116–122.

31. "A Commentary on 'A Communication made by the Rev. W. B. Clarke to His Excellency Sir Henry Barkly, K.C.B., etc., on Professor McCoy's new *Tæniopteris*,' etc., etc.": Victoria Roy. Soc. Trans., vol. v (1860), pp. 96–107.

32. "Note on the Ancient and Recent Natural History of Victoria": Ann. Nat. Hist., vol. ix (1862), pp. 137–150.

33. "On the Snakes of Victoria [1861]": Victoria Roy. Soc. Trans., vol. vi (1865), pp. 7–8.

34. "On the Bones of a new gigantic Marsupial, *Diprotodon* [1861]": ibid., p. 25.

35. "Remarks on a Series of Fossils collected at Wollumbilla [1861]": ibid., pp. 42–46.

36. "On the Occurrence of *Limopsis Belcheri, Corbula sulcata*, and some other Recent Shells in the Fossil State in Miocene Tertiary Beds, near Melbourne": Ann. Mag. Nat. Hist., vol. xvi (1865), pp. 113, 114.

37. "Notes on the Australian Species of *Arripis*": ibid., vol. xvi (1865), pp. 187–8.

38. "Note on the Cretaceous Deposits of Australia": ibid., vol. xvi (1865), pp. 333–4.

39. "On the Canine Teeth of *Thylacoleo carnifex*, Ow.": ibid., vol. xvi (1865), p. 448.

40. "On a new Species of *Halmaturus* (*H. Wilcoxi*) from East Australia": ibid., vol. xviii (1866), pp. 322–3.

41. "On some new Species of Fossil Volutes (*V. macroptera, V. Hannafordi, V. antiscalaris, V. anticingulata*) from the Tertiary Beds near Melbourne": ibid., vol. xviii (1866), pp. 375–381.

42. "On the Australian Tertiary Species of *Trigonia*": GEOL. MAG., Vol. III (1866), pp. 481–2.

43. "On the Discovery of Cretaceous Fossils in Australia": Victoria Roy. Soc. Trans., vol. vii (1866), pp. 49–51.

44. "On the Palæontology of Victoria (Australia)": Amer. Journ. Sci., vol. xliv (1867), pp. 279–282.

45. "On two new Species of Birds (*Pardalotus xanthopygus, Sphenura Broadbenti*) found in Victoria": Ann. Mag. Nat. Hist., vol. xix (1867), pp. 184–5.

46. "On the Occurrence of *Ichthyosaurus* and *Plesiosaurus* in Australia": ibid., vol. xix (1867), pp. 355–6.

47. "On the Recent Zoology and Palæontology of Victoria": ibid., vol. xx (1867), pp. 175–202.

48. "On a new Genus of Phalanger: *Gymnobelideus*": ibid., vol. xx (1867), pp. 287–8.

49. "Descriptions of two new Fossil Cowries (*Cypræa avellanoides, C. gigas*) characteristic of Tertiary Beds near Melbourne": ibid., vol. xx (1867), pp. 436–8.

50. "On a new Species of Victorian Honey-eater: *Ptilotis Leadbeateri*": ibid., vol. xx (1867), p. 442.

51. "On the Occurrence of the Genus *Squalodon* in the Tertiary Strata of Victoria": GEOL. MAG., Vol. IV (1867), p. 145.

52. "On three new Victorian Birds: *Herodias grezetta*, *Sphenura Broadbenti*, *Pardalotus xanthopyge*": Victoria Roy. Soc. Trans., vol. viii (1867), p. 41.

53. "On the Discovery of Enaliosauria and other Cretaceous Fossils in Australia": ibid., pp. 41, 42.

54. "On the Species of Wombats": ibid., pp. 266–270.

55. "Note on the *Phascolomys setosus*, Gray, and *P. niger*, Gould": Ann. Mag. Nat. Hist., vol. i (1868), pp. 30, 31.

56. "On a new Volute: *V. Thatcheri*": ibid., p. 64.

57. "The Australian Representative of *Cynthia cardui*": ibid., p. 76.

58. "On the Fossil Eye and Teeth of the *Ichthyosaurus Australis*, McCoy, from the Cretaceous Formations of the Source of Flinder's River; and on the Palate of the *Diprotodon*, from the Tertiary Limestone of Limeburner's Point, near Geelong": Victoria Roy. Soc. Trans., vol. ix (1868), pp. 77, 78.

59. "On the Spire of *Voluta Thatcheri*": Ann. Mag. Nat. Hist., vol. iv (1869), p. 140.

60. "On a new Volute: *Voluta* (*Amoria*) *canaliculata*": ibid., vol. v (1869), p. 34.

61. "On a new Australian Species of *Thyrsites*: *T. micropus*": ibid., vol. xi (1873), pp. 338–9.

62. "Note on the Appearance in Australia of the *Danais Archippus*": ibid., vol. xi (1873), pp. 440–1.

63. "On a new *Parascyllium* from Hobson's Bay [*P. nuchalis*]": ibid., vol. xiii (1874), p. 15.

64. "On a third new Tertiary Species of *Trigonia* [*T. Howitti*]": ibid., vol. xv (1875), pp. 316–7.

65. "Note on an apparently new Parrot [*Cyclopsitta Leadbeateri*] from Cardwell, N.E. Australia": ibid., vol. xvi (1875), p. 54.

66. "On a Tertiary *Pleurotomaria* [*P. tertiaria*]": ibid., vol. xvi (1875), pp. 101–2, 235.

67. "On a new Victorian Graptolite [*Didymograpsus Thureaui*]": ibid., vol. xviii (1876), pp. 128–30.

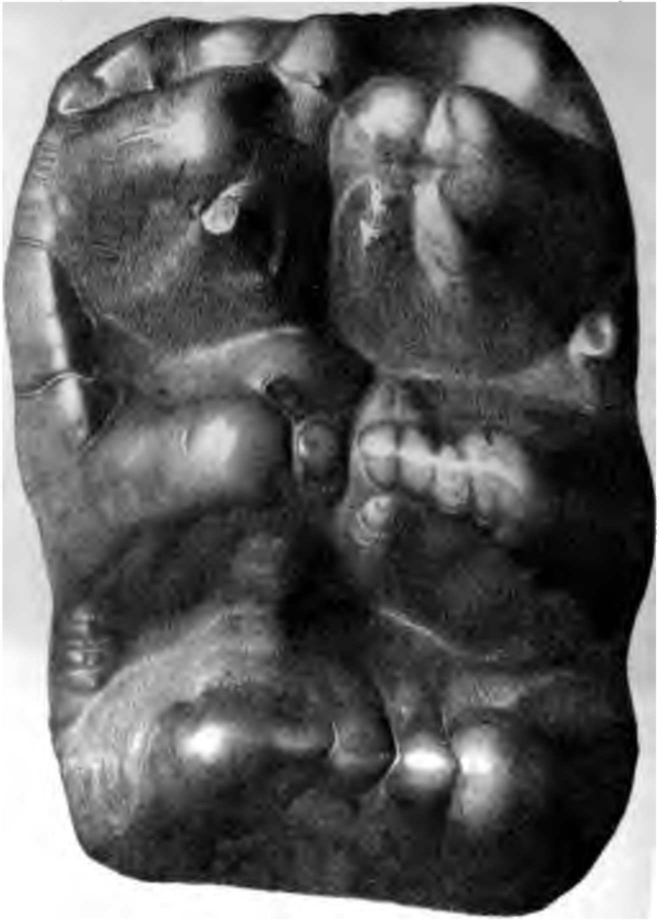
68. "On the discovery of the *Trigonia acuticostata* (McCoy), in the living state": ibid., vol. xviii (1876), pp. 273–4.

69. "Description of a new Volute [*Voluta Roadnightæ*], from the South Coast of Australia": ibid., vol. viii (1881), pp. 88, 89.

MISCELLANEOUS.

CAMBRIDGE HONOURS.—On Thursday, 27th April last, the University of Cambridge conferred the honorary degree of Doctor in Science upon Professor T. Wiltshire, M.A., F.L.S., F.G.S., F.R.A.S., so many years Secretary of the Ray and Palæontographical Societies and for some years Treasurer of the Geological Society of London, Emeritus Professor of King's College, London. The following was the speech delivered by the Public Orator in presenting Professor Wiltshire for the honorary degree of Doctor in Science:—"Unus ex alumnis nostris, societatis geologicae, astronomicae, Linnaeanae socius, idcirco praesertim inter peritos laudatur, quod palaeontographicae societatis in usum, palaeontologiae studiosorum ad fructum, aevi prioris monumenta a rerum natura in saxis impressa, non sine summo ingenio et labore illustrata, per annos plurimos litterarum monumentis mandaverit. Idem Universitatem nostram beneficio singulari ad sese devinxit, quod non modo bibliothecam suam, sed etiam vitae antiquae reliquias veteres in saxis conservatas et saxorum inter se diversorum exempla quam plurima, nuper nobis in perpetuum donavit. Illa vero exempla omnia, olim inter Londinienses in Collegio Regali professor, docendi praesertim in commodum collegerat, cum Horatio (ut videtur) arbitratus 'demissa per aurem quam quae sunt oculis subjecta' animum segnius excitare. Etiam ipsa fama liberalitatis tantae nuper inter nosmet ipsos inter rerum naturae praesertim studiosos animum gratum excitavit. Quanto magis juvat Universitatem totam liberalitatis tantae auctorem ipsum hodie oculis suis redditum et auspiciis optimis praesentem contemplari. Qui prioris aevi tot exempla nobis donavit, ipse nostro in saeculo munificentiae in Universitatem nostram ab aliis imitandum praebuit exemplum. Praesento vobis geologiae professorem emeritum, virum de rerum naturae studiis praeclare meritum, Thomam Wiltshire."

TESTIMONIALS TO PROFESSOR T. WILTSHIRE, M.A., D.Sc., F.L.S., F.G.S., F.R.A.S., ETC.—The President of the Palæontographical Society announces that a Committee has been formed consisting of present and past officers, members of Council, subscribers to the Palæontographical Society, and contributors to its publications, for the purpose of raising a testimonial to be presented to their valued Secretary, the Rev. Professor T. Wiltshire, M.A., F.G.S., etc., who, from 1863 to 1899, a period of 36 years, has so ably and efficiently carried on the affairs of the Society, and the issue of its annual volumes. The duties of Secretary are continuous, and at times arduous; and the Committee are of opinion that it would be well not to delay longer performing so agreeable a task as to offer Professor Wiltshire some slight recognition of the valuable services which he has rendered to palæontological science for so many years. They are anxious to make the testimonial as comprehensive as possible, and they hope to obtain the support, not only of all members of the Society, but of all who are interested in palæontology. They have therefore ventured to suggest a one-guinea subscription, without, however, debarring anyone who may desire to contribute more or less. Sir John Lubbock, Bart., has kindly consented to act as treasurer, and subscriptions may be sent, either direct by cheques to Messrs. Robarts, Lubbock, & Co., 15, Lombard Street, E.C., marked "For the Wiltshire Testimonial," or, if forwarded to Aubrey Strahan, Esq., M.A., F.G.S., the honorary secretary to the Committee, Geological Survey of England and Wales, 28, Jermyn Street, London, S.W., they will be duly acknowledged by him.—We understand that a similar wish has been expressed to recognize Professor Wiltshire's services in connection with the Ray Society, and that subscriptions are being received by John Hopkinson, Esq., F.G.S., The Grange, St. Albans, and by Sir John Lubbock, Bart. (the President of the Ray Society), as above. More than a hundred members of these Societies have already sent in their names and subscriptions, and many others will doubtless follow as soon as they are made aware of the proposal. It has been suggested that the testimonial, in part at least, should take the form of a presentation portrait, and arrangements have already been made with an able artist for carrying this object into effect as speedily as possible.



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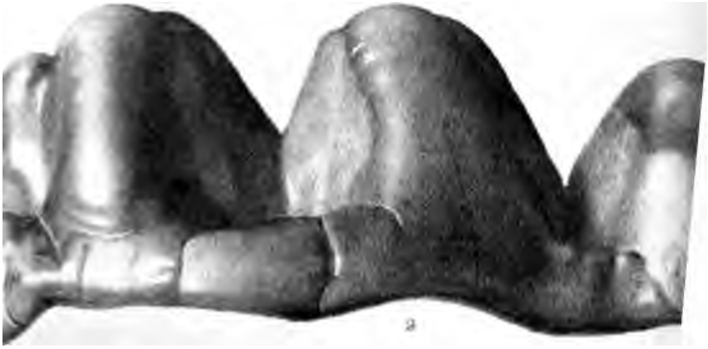

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Mastodon. Red Crag.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. VII.—JULY, 1899.

ORIGINAL ARTICLES.

I.—NOTE ON THE MOLAR OF A TRILOPHODONT MASTODON FROM THE BASE OF THE SUFFOLK CRAG.

By E. RAY LANKESTER, M.A., LL.D., F.R.S.,
Director of the Natural History Departments of the British Museum.

(PLATE XI.)

THE tooth figured in the accompanying plate was originally noticed by me in this Magazine thirty years ago, and was more fully described by me a year later in the Quarterly Journal of the Geological Society, 1870, p. 507.

At that time it was in the collection of Mr. Baker, of Woodbridge. It has since passed into the collection of the York Museum. I am greatly indebted to the authorities of that institution for lending it to me again for further study, and for allowing me to remove from the valleys between the transverse ridges of the tooth the remarkable matrix which formerly filled them up. (Compare the figure in the Quart. Journ. Geol. Soc., 1870, with that now published.)

The interest attaching to this tooth is twofold. In the first place it was determined by me to be the upper penultimate molar of a Trilophodont Mastodon, being a perfect enamel crown from which no portion had been detached. It thus differs from the well-known Tetralophodont Mastodon of the East Anglian area (*M. Arvernensis*). The completeness of the tooth-crown was recognized by all the palæontologists who saw the actual specimen, including the late Mr. George Busk, F.R.S., whose testimony on the subject I cited.

The second point of interest about the tooth is that its valleys were filled by a matrix which I was able to identify with the sandstone nodules called 'box-stones,' the true nature of which I had recently determined by collecting from every available source the shell-casts and other organic remains which they contain. It was shown that the 'box-stones' which occur abundantly at the base of the Suffolk Crag (and not in the Norfolk area) are the rolled fragments of a Diestien deposit, in all probability an extension of the Black Crag of Antwerp. The Trilophodont Mastodon was therefore necessarily a tenant of the land surface before the deposition of this Upper Miocene 'Black Crag.' In this respect it was shown to contrast with *Mastodon Arvernensis*, the teeth of which occur at the base of both the Suffolk and Norfolk Crags in a peculiar condition of mineralization, differing widely from that of the present specimen and from that of some other fragments of Mastodon teeth not referable to the species *M. Arvernensis*. The molars of *M. Arvernensis* from the East Anglian area are very seldom water-worn, and in many cases are found, not in the condition of 'enamel crowns,' but with the softer material which forms the fangs of the tooth still perfect. On the other hand, the teeth of *Rhinoceros Schleiermacheri*, of *Tapirus priscus*, of *Hipparion*, and some other mammals, which occur in the same deposit, are in the same water-worn condition and in the same state of mineralization as that which characterizes this Trilophodont Mastodon and some other fragments of Mastodon teeth referred by me to *M. tapiroides*. The conclusion to which I came was, that we have at the base of the Suffolk Crag successive sweepings (as it were) of the land surface, the latest (Pliocene) being represented by *M. Arvernensis* and possibly some other remains, an older sweeping by the Trilophodont Mastodon, other Mastodon fragments, and the *Rhinoceros*, *Hipparion*, and *Tapirus*, whilst a still older contribution is that of the Eocene land fauna indicated by *Coryphodon* and *Hyracotherium*.

The specific identification of the single penultimate Trilophodont molar was a difficult task, especially as the valleys were filled by matrix. After discussing the possible identification of the tooth with *M.* (*Trilophodon*) *Borsoni*, a Pliocene species, I came to the conclusion that the probabilities were in favour of its being referable to *M.* (*Trilophodon*) *tapiroides* (= *turicensis*, Pom.).

The chief reason which I have had for making a re-examination of this specimen is, that my main conclusion as to its nature has been directly traversed in two separate publications by Mr. R. Lydekker, F.R.S. I find that Mr. Lydekker had never examined the original specimen, but based his opinion on a coloured cast which I had presented to the British Museum. This cast did not show the under surface of the specimen at all, and therefore was devoid of any evidence which could justify the formation of an opinion as to the completeness or incompleteness of the enamel crown.

In a paper on Crag Vertebrata, Mr. Lydekker writes as follows (in the Quart. Journ. Geol. Soc., vol. xlii, p. 365, 1886):—"The evidence for the presence of *M. longirostris*, Kaup, is afforded by several fragments of molars in the British Museum,[1] and by the greater part of a second or third upper true molar[2] figured by Lankester in vol. xxvi, pl. xxxiv, figs 1, 2, of the Society's Journal, and regarded by him as the complete tooth of a Trilophodont species. The examination of the cast of the latter shows, however, without doubt, that it has lost one or more posterior ridges, and that, as suggested by Lartet,[3] it really belongs to *M. longirostris*, the form of the anterior talon and the separation of the inner and outer columns being decisive."

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[1] These and the preceding specimens were noticed by Lydekker in part iv of the British Museum Catalogue of Fossil Mammalia.

[2] Cast in British Museum.

[3] See Lankester, op. cit., p. 508.

In the fourth volume of the Catalogue of Fossil Mammalia, published by the Trustees of the British Museum (1886), p. 65, Mr. Lydekker records the cast presented by me as No. 48,427 in the collection, and declares it to be a cast of the first three ridges of the second or third left upper true molar of the Tetralophodont *Mastodon longirostris* of Kaup. He states that the original is described and figured by Lankester as the complete molar of a Trilophodont species, and proceeds—"The specimen has, however, lost a ridge, and agrees precisely with the corresponding portion of the molars of the present species (*M. longirostris*)." In a note Mr. Lydekker refers to Lartet's opinion of the 'specimen.' But as a matter of fact Mr. Lartet had never seen the specimen any more than had Mr. Lydekker. Both of them based their opinions on a very incomplete cast of a specimen, which was still largely obscured by matrix, and had never been seen by either of them.

There never was any doubt in my own mind as to the completeness of the enamel crown under discussion, and I am glad to be able to state that on examining the actual specimen, lent to me by the authorities of the York Museum last autumn, Mr. Lydekker at once admitted that the enamel crown *is* complete, and that his contention that it was not so is devoid of any foundation.

During its sojourn in the British Museum (Natural History) our skilled 'preparateurs' have removed from the 'Baker' molar the mass of matrix which filled up the two valleys. It is now, therefore, a more hopeful task than was the case thirty years ago, to attempt to arrive at a conclusion as to the species of Trilophodont Mastodon to which it should be referred.

The clearing out of the matrix from the valleys in our specimen has shown that the transverse ridges and valleys have by no means the simple and clean-cut character which is found in those of *Mastodon Borsoni*. The semi-detached columns on the sides of the first and second ridges and the sharp median incision traversing the whole tooth antero-posteriorly place this tooth in that middle group of Mastodons (so far as ridge structure is concerned) occupied by *Trilophodon angustidens* and *Tetralophodon longirostris*, a group lying between the simpler *Trilophodon Americanus* and *Trilophodon Borsoni* and the complicated *Trilophodon Humboldti* and *Tetralophodon Arvernensis*.

The *Trilophodon angustidens* of Cuvier is a Middle Miocene form to which several other species are related, perhaps only as local specializations. *M. Pyrenaicus* of Falconer and *M. tapiroides* (*turicensis*) are not remote from it. Specimens are preserved in the various museums of Europe which afford an almost complete transitional series between these three species. The most striking difference between *M. angustidens* and the two others is, that it has really narrow molars whilst the others have broad ones. Our Suffolk molar is remarkably broad in proportion to its length, broader, I should say, than any penultimate upper molar I have seen.

It has not so well developed a cingulum as have typical molars of *M. tapiroides* (*turicensis*), and the ridges are not so high in proportion to the other dimensions of the tooth. In place of the oblique fold of enamel traversing the face of each ridge which is seen in *typical* (but not in all) specimens of molars referred to *M. tapiroides*,[1] we have here a breaking up of the transverse ridge itself into semi-detached columns. On the whole it comes nearest amongst described molars to those called *M. Pyrenaicus* by Falconer. This *M. Pyrenaicus* is essentially a *Mastodon angustidens* which is not angustident, and that perhaps is the best description which can be given of the present tooth. I should be inclined, supposing that the species '*M. Pyrenaicus*, Falc.,' is to be considered as a synonym of *M. angustidens*, Cuv., to recognize such broad molars of the *M. angustidens* type as belonging to *Mastodon angustidens*, Cuv., var. *latidens*.

In any case we have to go to the Middle Miocene for the species with which to associate this Suffolk Mastodon, and this fact is well in harmony with the age indicated by the once adhering matrix, viz., one anterior to that of the Diestien or Black Crag of Antwerp.

EXPLANATION OF PLATE XI.

FIG. 1, view of the upper surface, and FIG. 2, side view of the trilophodont upper penultimate molar of *Mastodon angustidens*, var. *latidens*, from the base of the Red Crag of Suffolk, preserved in the Yorkshire Philosophical Society's Museum, York. Originally figured with its valleys still filled by the peculiar Diestien matrix, which has since been removed. (See Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 507, pl. xxxiv, figs. 1 and 2.) Drawn of the natural size.

II.—THE GLAUCOPHANE GABBRO OF PEGLI, NORTH ITALY.

By JOHN PARKINSON, F.G.S.

(PLATE XII.)

IN a paper published some years back on the Tuscan and Ligurian Serpentines[2] Professor Bonney has noticed incidentally the occurrence of glaucophane in the gabbro associated with these rocks at Pegli, a village to the west of Genoa; and later added a rather fuller description towards the end of his paper[3] on "The Glaucophane Eclogite of the Val d'Aoste." Last year I spent a few days at Pegli for the purpose of examining the rocks at the village and in its neighbourhood, when I found the gabbro in some abundance, in consequence, as I think, of blasting for road-making. The specimens then collected have disclosed on examination a few points of interest which may not, I hope, be deemed a superfluous addition to the accounts already published. Those have been rather numerous. Dr. G. H. Williams has briefly described[4] a glaucophane containing rock from this neighbourhood, which he calls an amphibolite, and, later, Stefani[5] has called in question the propriety of the term

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[1] Fragments of molars showing this typical fold have been recorded by me from Suffolk: Quart. Journ. Geol. Soc., 1870.

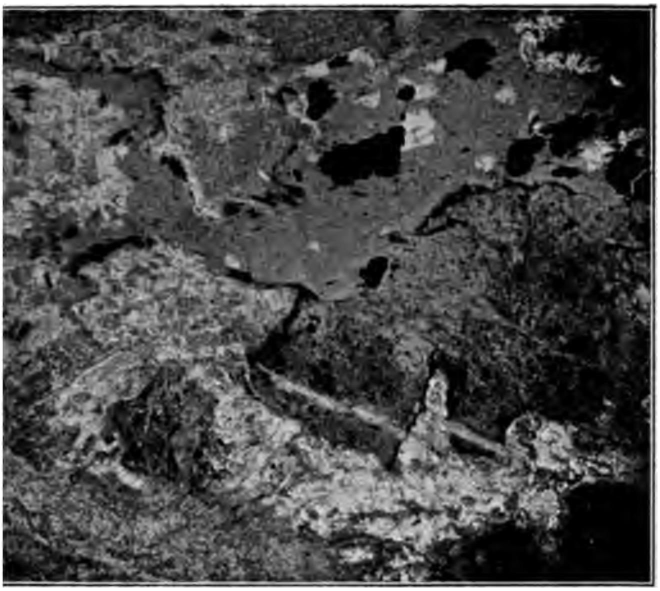
[2] GEOL. MAG., Dec. II, Vol. VI (1879), p. 363.

[3] Min. Mag., vol. vii (1885–7), p. 5.

[4] Neues Jahrb. für Min. Geol., 1882, Bd. ii, p. 201.

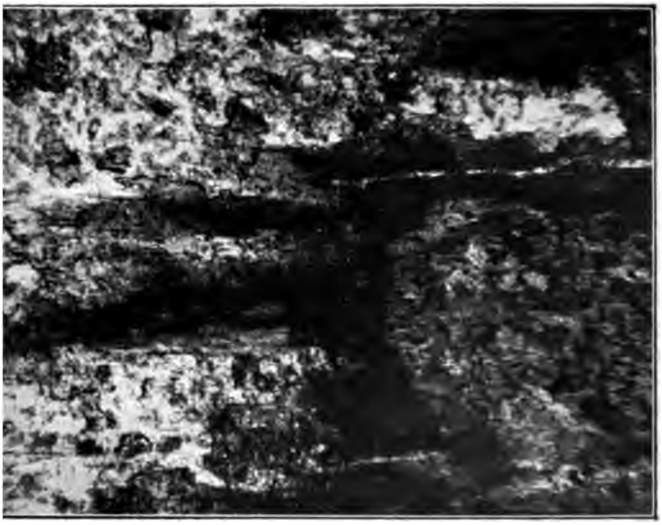
[5] Boll. d. Soc. Geol. Ital., vol. vi (1887), p. 233.

FIG. 1.



× about 8½ times.

FIG. 2.



× about 75 times.

Glaucophane *Gabbro* of Pegli, North Italy.

glaucophane gabbro for a rock "near Pegli." This he describes as being distinctly stratified, and as being characterized by possessing glaucophane in place of typical hornblende. Besides glaucophane the rock is said to contain plagioclase, commonly titanite or pyrites, and rarely quartz.

It is also worthy of remark that more recently a description has been published by Chelussi[1] of two glaucophane-bearing rocks from the island of Giglio, situated to the west of the Orbetello peninsula and not far south of the island of Elba. One of these is a gabbro in which a diallage alteration takes place, resulting in the formation of glaucophane, the dominant characteristic of the Pegli rock. The other he calls a diorite, and compares with the rock Professor Bonney and Professor Stefani have already noticed. He thinks that from the smallness of the constituents the rock might almost be called a microdiorite, but that it approaches an amphibolite in its rather schistose structure and in the abundance of its hornblende. The glaucophane is present either as flakes, as iregular tabular crystals, or as needles and fibres. The fact that these rocks present many points of resemblance to the one near Genoa is, I think, of interest. Both rocks are decomposed, that from Pegli the more so especially as regards the felspars, but the likeness is sufficiently striking.

M. Lacroix, in his work "Mineralogie de la France et de ses Colonies" (vol. i, p. 706), describes many instances in which secondary glaucophane results from the change—often a very complete one—effected in various gabbros. Speaking of those rocks from Villarodin, near Modane, he remarks that the production of glaucophane has been brought about by the usual methods of uralitization, and that it may also be found in the midst of an aggregate of epidote, albite, and calcite, which has resulted from the saussuritization of the felspars. The occurrence of diallage as the parent of glaucophane is apparently by no means uncommon, and has been recorded several times in addition to the instances which have been already mentioned. Professor Bonney, speaking of glaucophane crystals from the neighbourhood of Zermatt,[2] remarks that "their structure suggests to me the possibility of the replacement of a diallage"; Mr. Rutley,[3] in describing some glaucophane epidote schists from M. Viso, remarks that the rock contains a little diallage "sometimes enclosing numerous crystals of glaucophane"; and Professor Kotō,[4] writing on glaucophane from Japan, describes many rocks in which this mineral is secondarily developed from—as he believes—diallage; one of these he compares with the Pegli rock as regards the character of its groundmass. This author thinks the very finely fibrous glaucophane often present in these rocks is crocidolite, but owing to the nature of the mineral is unable to apply a decisive test. In describing the rock from the Val Chisone[5]

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[1] Atti R. Acc. Lincei, ser. v, Rendic. iv (1895), p. 466.

[2] Min. Mag., vol. vii, p. 7.

[3] Quart. Journ. Geol. Soc., vol. xlv, p. 60.

[4] Journ. Coll. Sci. Imp. Univ. Tōkyō, vol. i (1886), pt. 1; also Summary. Neues Jahrb. für Min. Geol., 1889, Bd. i, p. 36.

[5] Min. Mag., *vol. vii, pp. 191–3.*

Professor Bonney considers the probability that it had once been a dolerite, perhaps ophitic, the glaucophane resulting from the "molecular rearrangement of the constituents of an aluminous augite and labradorite."

Description.—The rock at Pegli is exposed at the western end of the village, on the beach and under the houses built out seawards from the left of the road. Macroscopically it is a dark rock, very tough, and usually without conspicuous felspars, though occasionally their remains give the rock the common black and white mottled look of an ordinary fairly coarse gabbro. The ferromagnesian constituent is much developed in the majority of cases, and in this the slaty-blue tinge of the glaucophane is conspicuous. In sections it is seen to be a diallage felspar rock usually altered throughout by secondary changes, and showing much glaucophane. In almost all cases it is clear that the diallage has contributed largely to the formation of the glaucophane, and the term glaucophane gabbro is therefore entirely applicable. The more usual change results in a well-marked rim to the altering diallage, accompanied by more or less definite flakes and scales of the same mineral in the body of the parent crystal. In some cases the flakes are grouped irregularly without semblance of orientation; usually, however, the relation is a definite one, flakes and films of glaucophane are scattered throughout the parent crystal, irregularly outlined and blotchily coloured, but replacing the diallage in the same crystallographic sense. In a few instances the diallage is changing into both glaucophane and a brown hornblende; when this takes place the two replacing minerals are intimately associated together. This arrangement of glaucophane and hornblende replacing diallage very closely resembles that described and figured by Lacroix in an euphotide from Villarodin.[1] The absorption along $\mathfrak{c}$ appears to me to be frequently greater than in either the island of Syra or in the Île de Groix rocks, for an examination of slides from which localities I am indebted to the kindness of Professor Bonney. This is the variety which Lacroix terms "glaucophane foncée," characterized by the following pleochroism: $\mathfrak{c}$, dark Prussian blue; $\mathfrak{b}$, violet blue; $\mathfrak{a}$, light greenish; yellow. This differs by its pleochroism from his "glaucophane normale," which has $\mathfrak{c}$ lavender blue, $\mathfrak{b}$ purple blue, $\mathfrak{a}$ colourless or yellowish. In the Pegli rock the two are closely associated, and replace one another indifferently; the "glaucophane foncée" may be either fibrous or platy in habit.

The glaucophane rim usually found bordering the diallage is nearly always more regular on its internal than on its external edge, as though the formation of the replacing mineral had been continued outwards as irregular root-like films and streaks into the surrounding material, often extending for a considerable distance with a lighter shade of blue. In some instances the irregular edge is practically identical with the "flame-like forms" assumed by the blue amphibole edging added to common hornblende which have been described by W. Cross[2] from Colorado. By the production of flakes of glaucophane in the body of the diallage, an entire replacement by the former mineral is obtained; the characteristic diallage striation remaining even when scarcely any trace of the original mineral can be seen. The formation of closely massed flakes of glaucophane in cracks which crushing has caused in the diallage is also common. Professor Kotō has described many similar cases in the paper previously mentioned. The diallage passes directly into glaucophane. The dark, rather yellowish brown of the former mineral is lost in great measure with some abruptness, and the characters of the glaucophane assumed. Frequently it is crowded with granular enclosures which are most probably an excretion or residuum from the manufacture of the secondary mineral. They occur abundantly in those flakes which can be certainly demonstrated to have arisen from the diallage, rather than in those films and scales whose origin from the pyroxenic mineral cannot be so readily determined. They are entirely absent from the diallage in its freshest condition, and when the glaucophane is traversed by cracks now filled by secondary minerals, the granular mineral is absent; from which may be inferred that it does not form where the facilities for the removal of material are easy. The habit and high polarization tints strongly recall epidote, and it is most probable that the major part of the lime has been used up in this way. The rather high iron percentage of glaucophane makes it probable that most of this constituent present in the diallage would be used in the formation of the former mineral, and the presence of some quantity of zoisite with the epidote may be inferred therefrom. In some sections the glaucophane appears as a closely packed mass of flakes, straight or slightly wavy; which are arranged in groups or bundles with a slight tendency to a radial disposition, and not unmixed with actinolite or a kindred mineral. In one or two cases this glaucophane becomes minutely fibrous, and is then probably the same as the mineral Kotō has termed crocidolite, and which he believes to result from an alteration of the glaucophane. Here and there, but not commonly, in the Pegli gabbro the pleochroism is different to that of either normal or dark glaucophane, and is characterized by a blue-green or sea-green tint. The variety is platy or fibrous, the former paler in colour. The occurrence of the nearly allied species crocidolite on or near the north-western coast of Italy has been recorded by M. Lacroix[1] from Cape Argentario, near Orbetello, and from the island of Gorgona, to the west and a little to the south of Leghorn. That from the first locality is formed from diallage. M. Lacroix states that in his opinion many secondary blue hornblendes, described as glaucophane, are really crocidolite. Such an instance may, he thinks, be found in the blue amphibole partly replacing pyroxene, which has been described as glaucophane from a rock occurring in South Central Spain.[2]

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[1] Min. de la Fr. et de ses Colon., vol. i, p. 681, fig. 14.

[2] Amer. Journ. Sci., T.S., vol. xxxix (1890), p. 368, fig. 2.

The same author[3] has noticed a variety of glaucophane distinguished

[1] Bull. de la Soc. Min. de Fr., vol. xiii (1890), p. 10.

[2] Comp. Rend., vol. cii (1886), p. 640.

[3] Min. de la Fr., vol. i, p. 700.

from the normal mineral by its higher extinction angle, and at the same time by a slight difference of pleochroism, consisting principally in a greenish shade parallel to c. This he considers intermediate to some extent between normal glaucophane and hornblendes poor in alkalis. Extinction angles high for glaucophane, up to (say) 20° or even higher, are found in the Pegli rock. In many instances the general appearance of the mineral and its connection with definite remnants of diallage indicate that the high extinction is due to its derivation from a pyroxene, but the pleochroism scarcely agrees with that given by Lacroix. When the depth of coloration is irregular the extinction is irregular also, and not well defined in relation to the pleochroism.

It seems perfectly reasonable to suppose that a local deficiency of soda during the process of glaucophane manufacture would lead to the formation of an actinolite at such a point, and that the withdrawal of the same constituent from established glaucophane would produce the commoner form of hornblende by an inverse process. The considerable proportion of alumina which glaucophane usually contains appears a difficulty to the understanding of this change to actinolite; but Foullon[1] has published an analysis of a very fibrous soda-bearing hornblende — practically identical with glaucophane — which he terms Rhodusite, and in which the alumina percentage is about half per cent. Unfortunately it is impossible to isolate the glaucophane from the Pegli rock, and an analysis cannot therefore be prepared. Judging from the literature of the subject, however, actinolite appears to be by no means the only mineral into which glaucophane may pass. Dr. Barrois, describing[2] the glaucophane rocks of the Île de Groix, mentions the change of the characteristic constituent into smaragdite; the change into crocidolite has been discussed by Kotō as mentioned above; Williams, in the paper already cited, has described a possible change to arfvedsonite in pebbles from Gesmagnano, and Columba[3] has recently proved an alteration into chlorite.

The character of the groundmass has been already briefly described by Professor Bonney. Its most remarkable point is the absolute reconstitution of the original felspar, so that no hard and fast line can be drawn between the altering diallage and the material in which it is set. This varies greatly from place to place. Prolongations of the glaucophane, detached scales and flakes of the same mineral, associated with abundant similar flakes of a rather dark-green and inert mineral, in many cases no doubt actinolite, though occasionally perhaps chlorite, lie scattered in a water-clear substance, which resolves itself, under crossed nicols, into a fine mosaic. Most of this is no doubt a secondary felspar, but it is only in very rare instances that the characteristic twinning places this beyond doubt. By diminution in the amount of actinolite and glaucophane, and by the appearance of a rather dirty and granular epidote, with perhaps occasionally zoisite, the character of the altered groundmass changes. White mica is occasionally met with in some quantity, at times constituting, in small closely felted flakes, nearly all the groundmass of the rock; at others including many of the colourless grains. Here and there the alteration has given rise to a brownish-black mineral, far from clear, but showing occasionally very roughly hexagonal and prismatic outlines, which from the extinction is probably monoclinic. No definite cleavage can be observed, and under a fairly high power the structure appears to be finely granular. This may be a somewhat unusual form of epidote. Characteristically it occurs in groups of close-packed grains, about ·1 mm. across, often pear-shaped in outline; but in many cases the dimensions of the individuals scarcely become apparent till the nicols are crossed. The polarization colours are low, but the impure character of the mineral may have something to do with this. An earlier stage in the life-history of this mineral is found in the indefinite clouds and patches of an opaque substance lying round and indistinguishable from the more definite grains. As a rule crossing the nicols discloses the presence of obscure individuals, but here and there even these are hard to discern; there is merely an even dissemination of blackish material with very little double refraction. In one or two slides long prismatic or acicular crystals (average size about ·12 mm. by ·016 mm.) are arranged in twos and threes in diverging groups; and locally are rather abundant. Those I think may possibly be actinolite. Their opaque appearance, due apparently to the amount of impurities contained, as well as their small size, renders an exact determination impossible. They are irregularly terminated, rather fibrous in structure, with a greenish tinge, and with weak double refraction. They are set as a rule in a closely felted mass of white mica, so that here, as in several other places, the more acid or felspathic element usually produced during the decomposition of one of the more basic felspars seems absent.

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[1] Sitz. Akad. Wien, vol. 100 (1891), pp. 169–171.

[2] Soc. Géol. du Nord, t. xi (1883–4), p. 50.

[3] Atti R. Accad. Sci. Torino, vol. xxix (1894), p. 416.

One or two accessory constituents remain to be noticed. In a few slides apatite occurs in some quantity, either in well-formed idiomorphic crystals—cross sections sometimes measure ·75 mm. across—or in groups of irregular grains. Such allotriomorphic outlines as these grains possess, together with a rather dusty appearance which the mineral has, were unlike the usual habit of apatite; and I am indebted to Mr. J. J. H. Teall, F.R.S., who very kindly examined the slide and made the determination for me, suggesting at the same time the usual molybdate test as a ready means of settling the point definitely. This was done, and since the usual yellow precipitate followed there can be no doubt that the mineral is really apatite. Pyrites is present in some quantity, sometimes showing idiomorphic outlines, and there is in addition a considerable quantity of ilmenite altered in greater or less degree to leucoxene. The sp. gr. of the gabbro as determined by a Walker's balance is 3·129. This is the mean of determinations made on several specimens, the results agreeing closely with one another. The sp. gr. of the more felspathic variety is 2·977.

Finally, I wish to express my indebtedness to Professor Bonney for the help he has afforded me in the preparation of these notes.

DESCRIPTION OF PLATE XII.

FIG. 1.—General structure of glaucophane gabbro. To the right and below th centre are three crystals of diallage, showing the dark border of glaucophane and, internally, dark patches of the same mineral. In reality nearly all th mineral is converted into glaucophane; the orthopinacoidal striation of th diallage is seen with difficulty in the figure. Above these crystals is much o a pale-green chloritic mineral with flakes of glaucophane, and in places wit a border of the same. In it can be seen large black patches of pyrites, an others of a water-clear substance. Near the centre and left-hand top corne are good examples of the altered groundmass. × about 8½.

FIG. 2.—The glaucophane fringe surrounding a crystal of diallage, itself almos entirely altered to the same mineral. The extension of the fringe into th altered groundmass of the rock is seen to the left of the figure. × about 75.

III.—OBSERVATIONS ON SOME BRITISH CRETACEOUS MADREPORARIA WITH THE DESCRIPTION OF TWO NEW SPECIES.

By ROBERT F. TOMES, F.G.S.

(PLATE XIII.)

ON the 24th of June, 1885, a paper by me, entitled "Observation on some imperfectly known Madreporaria from the Cretaceou Formation of England," was read at a meeting of the Geologica Society which, encountering an adverse report from the referee, wa with the consent of the Council, withdrawn by me, and publishe verbatim in the GEOLOGICAL MAGAZINE of the same year (Dec. III Vol. II, pp. 541-563, Pl. XIV), 1885. The present communicatio is a continuation as well as a correction of the former one, whic has become necessary from the acquisition of additional material Before, however, going into particulars respecting the several specie to be referred to here, I wish to offer a few remarks on certain o the genera.

Bathycyathus has been merged by the late Professor Duncan int *Caryophyllia*, but I am not at present prepared to accept tha alteration, a very strict revision of the latter genus being, accordin to my view, quite necessary before such forms as *Bathycyath Sowerbyi* are placed in it.

Cœlosmilia, as we learn from the same authority, is a subgenus onl of *Trochosmilia*; "the main distinction between the two types onl relates to the amount of endotheca."[1] While, however, expressin himself as above, Professor Duncan did not fail to note that *Cœlosmili* includes "a number of species with a well-defined facies." It i that well-defined facies, with certain important peculiarities in th development of the septa themselves, into the consideration of whic I do not here enter, that induces me to retain, at any rate for th present, the genus *Cœlosmilia* as defined by MM. Milne Edward and Haime.

Although no species of *Smilotrochus* is admitted in the presen paper, it is desirable that a few remarks should be made respectin

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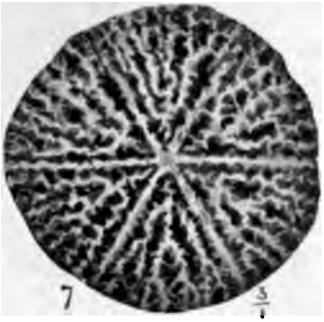
[1] Revision of the Families and Genera, 1884, p. 52.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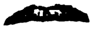
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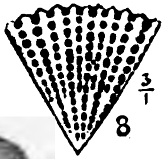
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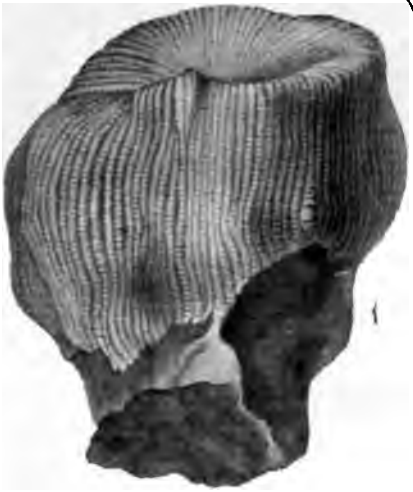
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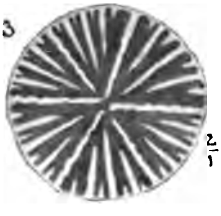
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R. F. Tomes del. S. Austin & Sons imp.

British Cretaceous Madreporaria.

the genus. It was created in 1851 by MM. Milne Edwards and Haime[1] for the reception of a single British species from the Greensand of Blackdown, *Smilotrochus tuberosus*, which they had already placed, though with doubt, in the genus *Trochosmilia*.[2] Afterwards, that is to say in 1857,[3] they brought two other species into the genus, one of them from the Farringdon Greensand, *Smilotrochus Austeni*, and the other, *S. Hagenowi*, from the White Chalk of Maestricht.

The "Introduction" of Dr. de Fromentel, which appeared in 1858–61, made no addition to or alteration of either genus or species; but in 1869 and 1870[4] Professor Duncan, while including the two British species above mentioned, added five others to the genus, making in all seven British species. In 1885 the present writer[5] described and figured an eighth; but both it and all those added by Professor Duncan have now been found to appertain to other genera. Moreover, *Smilotrochus tuberosus*, the very species on which the genus was founded, is in the present communication shown to be a *Placosmilia*. As a genus, therefore, *Smilotrochus* now rests on two species, *S. Austeni* and *S. Hagenowi*. Of the former so little is known that a re-examination is most desirable, and all the more so as so many simple Cretaceous corals have proved on close examination to appertain to genera characterized by the presence of a columella or pali, or of both.

Before entering into the details of the several species, I wish to record my indebtedness to Dr. Blackmore, of Salisbury, by whose kindness I have recently examined a collection of corals from the Chalk of that neighbourhood, some of which will shortly be mentioned. He has also favoured me with a section of the Salisbury Chalk, which enables me to place the several species in their precise position in the formation, and also to give their relative frequency, as follows:—

	Feet.	
1. Zone of *Belemnitella mucronata*, the highest beds, corresponding to the beds of Norfolk and Dorchester.	80	*Onchotrochus serpentinus.* *Cœlosmilia laxa.* *Parasmilia centralis.* ——— *Mantelli.* *Axogaster cretacea.*
2. Zone of *Actinocamax quadrata*, chiefly exposed at East and West Harnham, and worked for whitening.	170	*Parasmilia centralis.* ——— *Mantelli.* ——— *Gravensis.* *Cœlosmilia laxa.* ——— *regularis.* *Diblasus Gravensis.* *Stephanophyllia numismalis.* *Axogaster cretacea.*
3. Zone of *Marsupites*	230	*Caryophyllia cylindracea.* *Parasmilia centralis.* *Axogaster cretacea.*
4. Zone of *Micraster cor-anguinum*	250	*Caryophyllia cylindracea.* *Parasmilia centralis.* ——— *serpentina.*

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[1] Pol. Foss. Terr. Paleoz., 1851, p. 29.

[2] Brit. Fos. Cor., 1851, p. 58, pl. x, fig. 2.

[3] Hist. Nat. Cor., t. ii (1857), p. 71.

[4] Supp. Brit. Foss. Cor., pt. ii, No. 1, p. 19, and pt. ii, No. 2, p. 36 (1869–70).

[5] GEOL. MAG., December, 1885.

The comparative frequency of some of the species is as follows:—

Parasmilia centralis	200
——— *Gravensis*	4
——— *Mantelli*	38
Cœlosmilia (both forms)	64
Caryophyllia cylindracea	12

The small Madreporaria of the Gault are so beautifully preserved externally, and, from the cavity of the calice being almost always obscured, are so difficult to examine internally, that a few words on the best method of investigating their inner parts will not be out of place. To begin with, all idea of washing out the calice may be at once dismissed as altogether impracticable. Then there is the breaking up of the corallum in the hope that a fortunate fracture may reveal what lies in the bottom of the calice, which sometimes proves successful. But it is very uncertain work, and the following method of examination may with advantage be adopted in its stead.

Take a spoonful of fine plaster of Paris and well mix with it a sufficient quantity of lamp-black to make it of a pale slate colour; add water until it is of the consistency of thick cream. With this fill a small box—an ordinary pill-box will do very well—and place the coral, which must have been carefully removed from its matrix of Gault, vertically in it, with the calice only exposed. It should then be allowed not only to set, but to become thoroughly dry, when some thin gum-water must be dropped into the calice, and again be allowed time to dry. The whole can then be rubbed down until the bottom of the calice is exposed. I have found fine sand-paper, kept flat by attachment to a strip of wood, a good thing to rub down with, but great care must be taken to keep all the dust raised by the operation blown away as fast as made. A common blowpipe will do that quite successfully. If there is no destructive pyrites or hard phosphate present in the calice, the coral will then be seen in section, and present the appearance of a well-defined white figure on a dark ground, and the presence or absence of a columella or pali can be at once determined. It is the nearly white colour of the substance of the coral itself which renders desirable the mixture of lamp-black with the plaster, which, with a little care, will when dry have very nearly the same colour as the Gault matrix.

BATHYCYATHUS SOWERBYI, Edw. & Haime: Brit. Fos. Cor., 1850, p. 67, pl. ii, fig. 2.

Smilotrochus elongatus, Dunc. (in part): Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 19, pl. vi, figs. 1–6.

Trochocyathus conulus, Jukes-Browne (not Phillips): Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 303, pl. xiv, figs. 14–16.

After a most painstaking examination I am fully satisfied that all the specimens of the so-called *Smilotrochus elongatus* from the Coprolite Bed of the Cambridge Greensand must be referred to *Bathycyathus Sowerbyi*, and not, as was supposed by Mr. Jukes-Browne, to *Trochocyathus conulus*, and my reasons for arriving at that conclusion are as follows:—The broad and spreading foot *which is* so well shown in Mr. Jukes-Browne's figure (fig. 14) is precisely that of *Bathycyathus*, and is not characteristic of *Trochocyathus conulus*. The comparatively feeble development of the columella is also evidence in the same direction; but what is most conclusive is the fact that unquestionable specimens of *Bathycyathus* from the Folkestone Gault, when much worn and the wall and spreading foot partially or wholly absent, are undistinguishable from the Cambridge specimens, which, it should be remembered, are very rarely anything more than casts of the interior. It was Mr. Jukes-Browne, however, who pointed out that the Cambridge coral could no longer be retained in the genus *Smilotrochus*, and he subsequently showed that the so-called *Smilotrochus angulatus* must also be removed from that genus. Of the latter so-called species I can only say that I can follow Mr. Jukes-Browne in that conclusion, having observed in some of the Cambridge specimens the evidence of a small columella near the lower end of the coral.

CYCLOCYATHUS FITTONI, Edw. & Haime.

Micrabacia Fittoni, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 37, pl. xiv, figs. 6–9.

The specimen which I mentioned in my former paper as having been received from Dr. S. P. Woodward still retains its label in his handwriting: "*Cyclocyathus Fittoni*: Gault, Folkestone." It came to me in 1862, and has never been out of my hands, and every endeavour to obtain another specimen has proved futile.

The description and figure of *Micrabacia Fittoni* by Professor Duncan appeared in 1870,[1] but it is worthy of remark that in 1884, a year before the date of my paper,[2] he expressed some doubt as to the generic relationship of the type-specimen. There can be no doubt from the very close resemblance between my specimen and the figure of *Micrabacia Fittoni* as to the specific identity of the two specimens; and that there is a columella and pali in the one is beyond all doubt, while in the other the whole of the centre was so much obscured by extraneous matter that it is impossible to say what there may have been. The occurrence of only two specimens in the Folkestone Gault indicates the rarity of this form, whether we regard it as a variety of *Cyclocyathus Fittoni* or a distinct species.

TROCHOCYATHUS CONULUS. Phillips, sp.

Caryophyllia conulus: Phill. Ill. Geol. Yorks., 2nd ed., 1835, pl. ii, fig. 1.

Turbinolia conulus: Mich. Icon. Zooph., 1840, p. 1, pl. i, fig. 12.

Trochocyathus conulus. Edw. & Haime: Brit. Fos. Cor., 1850, p. 63, pl. ii, fig. 5.

Smilotrochus elongatus, Duncan: Supp. Brit. Fos. Cor., pt. ii, No. 2, p. 36, pl. xii, figs. 10–16; pl. xiii, figs. 10–12. (Not Jukes-Browne: Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 303, pl. xiv, figs. 14–16.)

Smilotrochus cylindricus, Duncan: Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 36, pl. xiv, fig. 16.

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[1] Quart. Journ. Geol. Soc., 1884, p. 565.

[2] GEOL. MAG., 1885.

The name of *Caryophyllia conulus* was given by Phillips in 1835 to a coral found in the Speeton Clay of Yorkshire; and having obtained a number of specimens from that locality which are obviously identical with the coral figured by Phillips, I have been enabled to compare and identify these with specimens from the Folkestone Gault, and to clear up the synonymy of the species.

Trochocyathus conulus, as I now restrict it, never attains to the size of the specimens from the Cambridge Greensand described by Professor Duncan as *Smilotrochus elongata*, which latter, it should be remembered, are only casts of the interior, and are not nearly so large as the perfect coral would be. The figures of *Trochocyathus conulus* given by Phillips and Michelin represent very full-sized examples, but most of the specimens from both Speeton and Folkestone are smaller and less regular in form.

Michelin gives two figures of this species, one being of an adherent coral and the other of one that was free. The latter is a good representation of *Trochocyathus conulus*, but the former is more like *T. Wiltshirei* than *T. conulus*, both of which species are found associated at Folkestone. In none of the specimens from Speeton which I have seen is there an adherent foot.

The more elongated corals from the Gault at Folkestone described and figured by Professor Duncan as *Smilotrochus cylindricus* occur also at Speeton They have both columella and pali, and are certainly *Trochocyathi*—indeed, nothing more than elongated individuals of *Trochocyathus conulus*.

TROCHOCYATHUS WILTSHIREI, Duncan.

Trochocyathus Wiltshirei, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, p. 34, pl. xiv, figs. 10–12.

Smilotrochus granulatus, Dunc.: loc. cit., p. 76, pl. xiv, fig. 17.

Since the appearance of my former paper in 1885 I have examined many specimens of this species, and while I am satisfied that it is a good one I am more than ever convinced that the so-called *Smilotrochus granulatus* is nothing more than the young form of it.

TROCHOCYATHUS? CALCARATUS, Tomes.

Smilotrochus calcaratus, Tomes: GEOL. MAG., 1885, p. 543.

Of this very peculiar species I can now say that its characters are by no means those of *Smilotrochus*. The ragged spines of the septa, which increase in size and prominence as they approach the fossula, obscure the latter part so much that examination is difficult, but they meet and blend in the centre of the calice, with what I have little doubt is a true but small columella. Moreover, in some of the better preserved calices there is a somewhat circular disposition of the spines around a centre, indicative of the presence of pali. And if there is both columella and a ring of pali, the species must be referred to the genus *Trochocyathus*.

Besides occurring in the Gault at Folkestone, the present species has been found in the Speeton Clay of Yorkshire, from which locality I have a well-preserved specimen, in which there are certainly *evidences* of the presence of a columella.

CERATOTROCHUS INSIGNIS, Duncan, sp.

Smilotrochus insignis, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 37, pl. xii, fig. 17; pl. xiv, fig. 18.

There is considerable doubt as to the generic place of this small species, but that it cannot retain its position in the genus *Smilotrochus* is most certain. In addition to the existence of a very distinct columella it is probable that there is a ring of pali, in which case it is a *Trochocyathus*. In fractured specimens there is to be seen surrounding the large columella a kind of outer ring having much the appearance of adherent and styliform pali, which, however, have a height corresponding with that of the columella, and may therefore be a part of it.

DIBLASUS, sp.

By the kindness of Mr. Jukes-Browne I have examined some much worn specimens of *Diblasus* from the Coprolite Bed of the Cambridge Greensand, and compared them with examples of *Diblasus Gravensis* from the Chalk of Gravesend. They are certainly specifically distinct, the costæ being small—only half the size of those of *D. Gravensis* — and much more regular in size and prominence. In none of the specimens are there any calices, and I refrain from further description.

PLACOSMILIA TUBEROSA, Edw. & Haime, sp.

Turbinolia compressa, Morris: Cat. Brit. Fos., 1843, p. 46.

Trochosmilia ?, tuberosa, Edw. & Haime: Brit. Fos. Cor., 1850, p. 58, pl. x, fig. 2.

Trochosmilia tuberosa, Morris: Cat. Brit. Fos., 2nd ed., 1854, p. 68.

Smilotrochus tuberosa, Edw. & Haime: Pol. Fos. Paleoz., 1851, p. 29; Hist. Nat. Cor., 1857, tom. ii, p. 71.

Placosmilia cuneiformis ?, Duncan (not Edw. & Haime): Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 27, pl. x, figs. 1–5.

A single specimen from the Greensand of Blackdown, which formed part of the collection of my late friend Dr. Wright, and is now before me, has the peculiar swellings near the foot which gave to the species its specific name; and although they are not quite so conspicuous as in the figures given by MM. Milne Edwards and Haime, there is no doubt as to the species.

The Blackdown specimen has a deep-seated and not very strongly formed columella, extending the whole length of the fossula, which is more than half the length of the calice, and its presence removes the species at once into the genus *Placosmilia*, and confirms its specific identity with the small deltoid corals from the Haldon Greensand regarded by Professor Duncan as the *Placosmilia cuneiformis* of MM. Milne Edwards and Haime; a wholly distinct and dissimilar species occurring in the Gosau deposits, as I have determined by the comparison of undoubted specimens from the last-named locality.

The Haldon specimens correspond very closely in general size and form with the one from Blackdown, and especially in the length and degree of development of the lamelliform columella, but differ in having the tuberosities at the foot only feebly indicated, and the ribs on the sides of the septa more strongly marked. I have examined a considerable number of these small *Placosmiliæ* from Haldon, but they are merely siliceous casts, and so badly preserved that had I not the advantage of a well-preserved specimen from Blackdown for comparison, I should hesitate to speak decisively of them, excepting to determine with absolute certainty their distinction from the Gosau specimens of *Placosmilia cuneiformis.* The latter are perfectly distinct from the Blackdown and Haldon specimens.

TROCHOSMILIA SULCATA, Edw. & Haime: Brit. Fos. Cor., 1850, p. 68, pl. ii, fig. 6.

I notice this species only to record its great rarity, one specimen alone amongst several hundreds from the Gault at Folkestone having reached me; and I may make the same observation respecting the extremely pretty *Leptocyathus gracilis*,[1] a single specimen being all that has appeared.

PARASMILIA GRANULATA, Duncan: Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 13, pl. vi, figs. 5–8.

The present species was founded on one or more specimens in the Dixon Collection, but as no indication of locality has been made known, I take the opportunity of recording some examples which were in the collection of Dr. Wright and came to me labelled in his handwriting, "*Monocarya centralis*, W. C. Brighton." They accord well with the figures and description given by Professor Duncan, but one of them is of greater size than the types, having a height of 1 inch 4 lines and a diameter of calice a little exceeding 10 lines. It has the largest calice of any British *Parasmilia* I have yet seen.

PARASMILIA MANTELLI, Edw. & Haime: Brit. Fos. Cor., 1850, p. 49, pl. viii, fig. 2; Hist. Nat. Cor., 1857, tom. ii, p. 173.

The original describers of this species had access to one specimen only (from Bromley in Kent) when diagnosing the species, and Professor Duncan does not appear to have seen a single specimen even, but was of opinion that it was only a variety of *Parasmilia Gravesana*, which he reduced to the rank of a subspecies. By the kindness of Dr. Blackmore, of Salisbury, who has favoured me with a number of *Parasmiliæ* from the Chalk near that town, amongst which are several specimens of *Parasmilia Mantelli*, I can without hesitation restore the species to its former place. There can be no doubt as to its distinctness from *Parasmilia centralis* and *P. Gravesana*, and, indeed, from all the other British species of the genus; but I must make an addition to the otherwise very exact description of MM. Milne Edwards and Haime, and note the existence of a very large and rather elaborately developed columella, which attains in one specimen to quite one-third of the diameter of the calice.

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[1] *Duncan*: "Supp. Brit. Foss. Cor.," pt. ii (1870), No. 2, p. 34, pl. xiii, figs. 5–8.

COELOSMILIA REGULARIS, sp. nov. Plate XIII, Figs, 2, 3, 4.

The corallum is small, turbinate, straight or a little curved, and attached by a very small foot, and there are distinct but not prominent annular swellings indicating periods of growth. The costæ are very indistinct, almost obsolete at the foot, but more defined near the calice. They are sub-equal, and alternately finely granulated and papillated.

The calice is symmetrical, circular or a little ovoid, and rather deep; the margin well defined, thin, and prominent, and the fossula small, deep, and a little elongated.

There are four cycles of septa in six systems; they are straight in their entire length, regular, not exsert, and their margins present a regular curvature from the wall downward into the fossula. Those of the first cycle almost meet in the centre of the visceral cavity, and are undulating in the direction of a horizontal line across them from the wall to the fossula. The undulations form broad, flattened, vertical ridges and furrows on the sides of the septa; the ridge on one side corresponding with the furrows on the other. The septa of the second cycle are three-fourths the length of the primary ones, and those of the third are a little more than half the length of those of the first cycle, while the septa forming the fourth are short, but vary considerably in different calices.

	in.	lines.
Height of the corallum	1	0
Diameter of the calice	0	6½

A larger specimen, showing periods of growth, has a length of 1 inch 9 lines, but has a calice of no larger dimensions than that given above.

The present species may be readily distinguished from all the other British species by the great regularity in the form of the calice, and in the development of the septa, as well as by the number of the cycles, and by the length of the septa forming the fourth cycle.

Hab.—The Upper Chalk of East and West Harnham, Salisbury, and the Upper Chalk of Brighton.

COELOSMILIA LAXA, Edw. & Haime.

This was the only British species of the genus accessible to MM. Milne Edwards and Haime when they wrote their history of British fossil corals, and of it they observe, "the septa are very unequally developed, broad, very exsert," and "those of the first and second cycla (*sic*) united along the lower part of their inner edge." In all the specimens from the Norwich Chalk which I have seen that irregularity is so remarkable that I have wholly failed to define the cycles, and have been obliged to satisfy myself by merely counting the septa. Including those which are merely rudimentary, I find in the largest corallum 68 septa, or four cycles, and 20 septa of the fifth cycle. In another having a calice only a little smaller there are 43 septa only. A third specimen has 44 septa. A fourth specimen, with a calice much reduced in size by recent rejuvenescence, has only 32 septa. Other specimens which I have examined have only confirmed the great irregularity of septal development in the genus *Calosmilia*, in so far as *C. laxa* is concerned; and as the same thing has been noticed in *C. poculum*, *C. Faujasi*, and *C. punctata* by MM. Milne Edwards and Haime, and in *C. Woodwardi* by Professor Duncan, we are justified in regarding it as having more than specific value, and as, I think, of more than subgeneric significance.

Of the Jurassic representatives of the genus *Calosmilia* reputed to have been found in the Nattheim Oolite, I am unable to speak.

RHIZANGIA MAMMILIFORMIS, Dunc., sp.

Podoseris mammiliformis, Dunc.: Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 25, pl. ix, figs. 2–15.

I have examined several other specimens of this coral since the appearance of my paper in 1885, in which the stolon connecting the corallites is well preserved and obvious. I regret, however, that the opportunity has not occurred for examining any of the earlier known species of *Rhizangia* by means of sections, and ascertaining whether their septa have a pseudo-synapticular growth or not. There is no doubt whatever that the present species has septa which do not differ materially in structure from those of *Thamnastrea* and that there are also tabular dissepiments between them.

Of the second species, *Rhizangia elongata*, there is great doubt respecting its specific distinction. The taller the specimen, the more irregular is the outline; the smaller and more deformed the calice, the more abnormal is the cycle of septa. In fact, the elevated specimens present much the appearance often seen in other simple forms, namely, an abnormal and excessive growth, just what is not uncommon in certain species of *Montlivaltia*. *Rhizangia elongata* is at best a doubtful species.

LEPTOPHYLLIA CLAVATA, Reuss.

Leptophyllia clavata, Reuss: Denk. der Wiener Akad. der Wiss., 1854, t. vii, p. 101, pl. vi, figs. 3–6.

Turbinoseris de Fromenteli, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, p. 42, pl. xv, figs. 13–18.

Leptophyllia Anglica, Tomes: GEOL. MAG., 1885, p. 551.

Continued investigation has made it quite obvious that the coral which Professor Duncan described as *Turbinoseris de Fromenteli*, and which I subsequently named *Leptophyllia Anglica*, is nothing more than the *Leptophyllia clavata* of Reuss, the very species on which the genus *Leptophyllia* was founded.

LEPTOPHYLLIA IRREGULARIS, Reuss. Plate XIII, Fig. 1.

Leptophyllia irregularis, Reuss: Denk. der Wiener Akad. der Wiss., 1854, t. vii, p. 101, pl. vi, figs. 2, 3.

One instance only of the occurrence of this fine species in this country has come to my knowledge. It was obtained by Mr. F. H. Butler from the Lower Greensand at Sandown, Isle of Wight, out of the same bed which has supplied the *Leptophyllia clavata*. I have compared the specimen, which is large one and in fine preservation, with specimens of *Leptophyllia rregularis* from Gosau, and find that, although it differs a little rom them in having rather thicker septa and costæ, it corresponds every other particular, and so closely that the identity of the pecies cannot be doubted.

STEPHANOPHYLLIA NUMISMALIS, sp. nov. Plate XIII, Figs. 5–8.

The corallum is subcircular and much depressed, the upper rface having but little convexity and the outer edge being very in. The base is a little concave. The basal wall is much erforated, much more so than in *Stephanophyllia Bowerbanki*, ough less so than in *S. radiata*. The mural costæ are rather icker than in *S. Bowerbanki*, and not so closely placed, the perforated paces between them being nearly their own breadth. There are bout fifteen perforations between each pair of costæ, but the number somewhat variable. The costæ anastomose less freely than in *Bowerbanki*, and there are no indications of dissepiments etween them.

The columella is rudimentary and depressed. The primary septa re straight, and pass into the columella; they are relatively rather in and very irregular. The secondary septa are a little shorter han the primary ones; those forming the third cycle anastomose ith the secondary ones near the columella, and the septa of the urth cycle pass into those of the third at about half their length, hile the septa constituting the fifth cycle join those of the fourth at point approximately to their middle. There are some short and ry irregularly developed septa of the sixth cycle anastomosing th the others. All the septa have margins which are excessively ged (lacerated is the word used by MM. Milne Edwards and ime), and the prominent angular points have the appearance of g twisted or bent in different directions.

Diameter of the corallum	...	...	...	5¼ lines.
Height of the corallum	...	...	...	1 line.

e specimen only has been met with. It was obtained from the of *Actinocamax quadrata* in the Upper Chalk at East Harnham, Salisbury, and is in the museum of that city. I am indebted to lackmore for the opportunity of describing and figuring this nd interesting species.

DESCRIPTION OF PLATE XIII.

Leptophyllia irregularis, Reuss, the corallum, natural size.
Cœlosmilia regularis, the corallum, natural size.
,, ,, the calice, magnified twice.
,, ,, a septum, magnified three times.
Stephanophyllia numismalis, the corallum, natural size.
,, ,, the same, seen in profile.
,, ,, the calice, magnified three times.
,, ,, a portion of the basal wall showing the intercostal perforations, magnified three times.

IV.—GLACIATED VALLEYS IN THE FAROES.

By JOSEPH LOMAS, A.R.C.S., F.G.S.

THE interesting paper by Mr. Harker in the GEOLOGICAL MAGAZINE of May, 1899, on "Glaciated Valleys in Skye," recalls to my mind many similar observations I made in the Faroes in the Summer of 1894. Not only are the valleys excavated out of homogeneous rocks, but the Faroes, like the Cuillins, had a glaciation of their own. It may be advisable, then, to call attention to some points which resemble those referred to by Mr. Harker, as well as others which are not seen in Skye.

The Faroes consist of a group of islands twenty-six in number. They have a trend approximately N.W.–S.E., and lie, with one or two exceptions, side by side, as if threaded on a line running N.E.–S.W. The islands are separated by long narrow fiords, and are evidently the result of erosion; no structural peculiarities in the great plateau of basalt suggest any other conclusion. A line drawn from Fuglo on the east to Myggenaes on the west gives the line of water-parting of the present day, as well as the ice-shed which obtained when the islands were glaciated. Soundings taken along the fiords show that they are shallow when the line crosses, and deepen N.W. and S.E. Into the fiords numerous cirques open on both sides.[1] Some of them are simple U-shaped valleys which have their floors above, at, or even below sea-level. Others descend in great steps towards the fiords, the curves embracing the tiers widening as they approach sea-level. Besides the simple forms, others are seen, which I have called compound or clustered cirques.[2] They consist of several U-shaped valleys which open into a common valley. We may compare them with leaves of shamrock, and they have evidently been determined by the courses of the rivers and their tributaries which eroded the plateau in Pre-Glacial times. The common valleys into which the tributary cirques open are not always straight, but trend towards the N.W. north of the line of ice-shed and towards the S.E. south of the line. This feature is particularly noticeable in the fiord which separates the two largest islands, Stromo and Ostero, from each other.

Extensive erosion has taken place since the Glacial period, for we find in some places a cluster of small islands, whose outlines show that at one time they formed part of one great cirque. Thus the remarkable island of Tindholm, and the Drangas associated with it, are all contained in one great basin-like curve. In many instances along the west and north coasts the cliffs are very lofty and imposing. They average over a thousand feet, and in places, e.g. Myling Head, present a sheer vertical wall over two thousand feet in height. When followed inland, however, the surface is often found to descend very rapidly into a great cirque, in some cases even below sea-level. A very fine example of this is seen near Tiornevig. Sailing northwards past the towering walls of Myling Head, we urn eastwards and at once come into the basin of a great cirque which falls in one grand curve two thousand feet. Myling Head, ike many other parts of the coasts, is a mere narrow ridge of rock, separating the sea on one side from a cirque valley on the other.

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[1] See Glacialists' Magazine, June, 1895; and J. Geikie, T.R.S.E., vol. xxx, pt. 1, p. 218.

[2] *Glacialists'* Magazine, June, 1895.

It is hardly possible to enumerate all the cirque valleys which exist in the Faroes. They abound in all the larger islands, and arns occupying true rock-basins are frequently seen on their floors.

NOTICES OF MEMOIRS.

The Parent-rock of the Diamond in South Africa. By Professor T. G. Bonney, D.Sc., LL.D., V.P.R.S.[1]

So much has been written on the occurrence of diamonds in South Africa, that a very few words may suffice as preface to this communication. References to many papers on the subject are given in "The Genesis and Matrix of the Diamond" (1897), by the late Professor H. Carvill Lewis,[2] and others have been published since that date.[3] It may suffice to say that the diamond, first discovered in 1867 in gravels on the Orange River, was found three years later in certain peculiar deposits, which occur locally in a region where the dominant rock is a dark shale, sometimes interbedded with hard grits, or associated with igneous rocks allied to basalt. These deposits occupy areas irregularly circular in outline, and bearing a general resemblance to volcanic necks. The diamantiferous material, near the surface, is soft, yellowish in colour, and obviously much decomposed; at a greater depth it assumes a dull greenish to bluish tint, and becomes harder. At the well-known De Beers Mine, near Kimberley, the works in 1898 had been carried to a depth of about 1,500 feet, and the diamantiferous material, for at least the last 100 yards, was not less hard than an ordinary limestone. It has a brecciated aspect, the dark, very minutely granular, matrix being composed mainly of serpentine (about four-fifths of the whole), and of a carbonate of lime (with some magnesia and a little iron). In this matrix are embedded grains of the following minerals: Olivine, enstatite, smaragdite, chrome-diopside (omphacite of some authors), a brown mica, garnet (mostly pyrope), but more than one variety observed, magnetite, chromite, ilmenite, with several other minerals much more sparsely distributed.

Rock fragments are also present, variable in size, but commonly not exceeding about an inch in diameter, as well as in quantity.

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[1] Being a paper read before the Royal Society on June 1st, 1899.

[2] Edited by the present writer.

[3] Jules Garnier, Geol. Soc. South Africa Trans., 1897, p. 91; H. S. Harger, ibid., p. 124. See also W. G. Atherstone, ibid., 1896, p. 76; L. De Launay, Compt. Rend., vol. 125 (1897), p. 335. The last author, in "Les Diamants du Cap" (Paris, 1897), gives a very full account of the mines, but an even better one will be found in Max Bauer, "Edelsteinkunde" (Leipzig, 1896, p. 208).

These, occasionally, but not generally, are rather abundant. In some cases they are chips of the neighbouring black shale, but in others they are greyish-coloured with a somewhat porcelainised aspect. The latter are generally subangular in form and externally banded or bordered with a darker tint; crystalline rocks have also been noticed, though these appear to be far from common, such as granite, diorite, and varieties of eclogite.[1] As to the genesis of the diamond, more than one opinion has been expressed. Professor Lewis regarded the matrix as a porphyritic form of peridotite, once a lava, now serpentinised,[2] in which the diamond had been formed by the action of the molten rock on some carbonaceous material (probably the Karoo shale). Others regarded the matrix as a true breccia, comparing it with the agglomerates in volcanic rocks. But among the latter, some thought that the diamond had been produced *in situ* by the action of steam or hot water in a subsequent solfataric stage of the volcano, while others (including myself) held that it had been formed, like the garnets, pyroxenes, etc., in some deep-seated holocrystalline mass which had been shattered by explosions.[3]

The specimens which I am about to describe were obtained at the Newlands Mines, West Griqualand; from 40 to 42 miles from Kimberley, almost due N.W. Here the workmen occasionally came across well-rounded boulder-like masses of rather coarsely crystalline rock, studded with garnets, which are sometimes about a foot in diameter. Specimens of these were found or obtained by Mr. G. Trubenbach, the London manager of the Newlands Diamond Mine Company, during a visit to the mines in 1897. His interest had already been aroused by picking up a specimen, presently to be noticed, in which some small diamonds occurred, very closely associated with a garnet; so the boulders were brought back by him to England. On careful examination a small diamond was detected on the surface of one of these. On breaking the boulder others were revealed. The most interesting fragment was sent by Mr. Trubenbach to Sir W. Crookes, who showed it to me. Examination with a hand lens convinced me that the rock could not be a concretion of the 'blue ground,' but was truly holocrystalline and allied to the eclogites. Sir W. Crookes generously waived his own claim to study the specimen, and obtained for me permission from Mr. Trubenbach to have slices cut from it. I gladly take this opportunity of expressing my gratitude to both gentlemen; to Sir W. Crookes for allowing me to carry out this interesting investigation, and to Mr. Trubenbach for his great liberality in placing at my disposal a considerable suite of specimens (including other boulders) from the Newlands Mines, and for the trouble which he has taken in affording me the necessary information.

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[1] A. W. Stelzner, "Sitzungsber. u. Abhandl. der Isis" (Dresden), 1893 (April), p. 71, calls attention to the fact that these show signs of attrition and that they range in size from a few cubic millimetres upwards, being sometimes large boulders. Among the materials (at Kimberley) he mentions both granite and eclogite.

[2] For the rock itself he proposed the name 'kimberlite.'

[3] In other words, that the volcano (as occasionally has happened) had ejected *little or no lava or scoria, discharging only steam and hot water, with shattered rock. This view is held by Max Bauer, in "Edelsteinkunde," p. 225, which, however, I had not seen when this paper was written.*

Prior to the discovery just mentioned, one or two instances had occurred at the De Beers Mine of a diamond apparently enclosed by or projecting into a pyrope. One such, the garnet being the size of a rather large pea, is in the collection at Freiberg (Saxony), to which it was presented in 1892.[1]

The specimen found by Mr. Trubenbach at the Newlands Mine was a piece of blue ground, with a pyrope projecting from one angle. A small, apparently broken, diamond seems embedded at the top. The others (five) are well crystallized, two on one side, three almost in contact on the other. The pyrope (which has a kelyphite rim) seems to be indented by two, but to have once included the others, as they are in contact with the unaltered mineral. We were thus brought so far as to associate the diamond with the pyrope; though this proved no more than the presence of garnets in the parent rock of the diamond, and thus made the eclogite (already known to occur) highly probable, for, as observed by Professor R. Beck,[2] the specimen itself is blue ground. In confirmation of his statement I pulverized a fragment,[3] and find that the powder corresponds with the matrix of the blue ground when similarly treated. The latest discoveries enable me to complete the chain of evidence.

ECLOGITE BOULDERS CONTAINING DIAMONDS.

The first-named, that containing several diamonds, is a fragment (perhaps from a quarter to a third) of a boulder, which probably was ellipsoidal in shape, two of the axes being nearly equal and the third distinctly the longest. We may infer that it was rounded from a roughly rectangular block, since the curved surfaces are slightly flatter in the middle parts. The axial lengths in the fragment (prior to removing a piece from one end) were approximately 4 in. by 3 in. by 2 in. The rock is coarsely granular, apparently composed of two green-coloured minerals, one darker than the other (possibly only different states of a single mineral), and of rich resin-pink coloured garnets, varying in size from a hemp seed to a pea, with slightly irregular distribution. The outer surface of the boulder, except for a very small 'step' on one side, is smooth, the garnets barely, if at all, projecting. The latter are covered with a rather soft, dark skin, sometimes slightly thicker than the thumb nail, which often has partly fallen off. This, as can be seen on the broken surfaces, becomes less conspicuous in the inner part of the boulder, and is sometimes invisible to the unaided eye. Two small diamonds are exposed on the curved outer surface, one about half, the other about one-fifth, of an inch from the edge of the cross fracture. On the latter surface, nearly an inch below the last-named, three small diamonds appear to lie in a line touching one another, and near them are two others,[1] all four within a space about three-quarters of an inch square; an eighth diamond is about an inch and a half away (on the same face); a ninth, about one-fifth of an inch from the top edge; and a tenth occurs on the larger cross-fractured surface, but near to the edge of the other one. These diamonds are octahedra in form, generally with stepped faces—one, at least, apparently twinned—perfectly colourless, with brilliant lustre; the largest being quite 0·15 inch from apex to apex; the smallest not exceeding 0·05 inch. All seem to be embedded in the green part of the rock. As the outer part of the boulder looks rather more decomposed than the inner, I had a piece removed from one end, thus enabling me to study the mass to a depth of more than an inch from the surface, and examined a strip, about 4 inches long, in a series of five slices.

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[1] A. W. Stelzner, "Sitzungsber. der Isis zu Dresden," 1893, s. 85, and R. Beck, "Zeitsch. für praktische Geologie," 1898 (May), p. 163.

[2] Ut suprà.

[3] I could not advise Mr. Trubenbach to have a slice cut from the specimen, as I feared it might be injured, but he kindly detached a little fragment from the opposite end to that named above, which I have thus examined.

The late Professor Lewis has given, in the volume already mentioned, so full an account of the minerals which occur in the 'blue ground,' that it will be needless on the present occasion to do more than refer to his descriptions,[2] only calling attention to any variations in the mineral constituents and their association in these eclogites. The constituents are:—

1. (*a*) *Garnet* (Pyrope).—In the slice these appear a light tawny or yellowish red tint, retaining this tint (though much lighter) under the microscope.[3] They are generally clear, with frequent and irregular cracks, but are occasionally traversed by wavy bands of minute enclosures of a pale brown filmy mineral, which is rather irregular in outline, very feebly pleochroic, and gives with crossed nicols fairly bright polarization tints. Similar minerals sometimes have formed along the cracks. They are probably mica, or possibly chlorite, and indicate incipient decomposition. The garnets towards the outside of the boulder, as already said, are enveloped in a 'skin,' and the microscope shows that it usually exists inside, though there it is thinner. In the former case it is generally browner in colour and more distinctly crystalline, corresponding in cleavage, pleochroism, etc., with a mica of the biotite group; in the latter it is greener and more filmy with an aggregate habit and seems to project into the garnet. I regard it as due to decomposition, a form of the well-known kelyphite rim, sometimes a mica, sometimes a chlorite, possibly now and then associated with a little minute hornblende. In a few cases a 'rim' is brown in the outer part and green within. The constituents tend to a parallel rather than a radial grouping. The garnets occasionally contain minute branching root-like enclosures grouped in bands. Though these

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[1] It is possible that these two form a twin crystal, but I think they are separate. As the point is unimportant, I have not attempted to clear away the matrix.

[2] We must also not forget the paper by Professor Maskelyne and Dr. Flight (Quart. Journ. Geol. Soc., vol. xxx, p. 406), in which several of these minerals are described, analyzed, and identified. In fact, the authors ascertained everything that was possible with the materials then obtainable.

[3] Unless it is expressly stated, the use of a 1 in. objective may be assumed.

act on polarised light, I regard them as empty cavities, and attribute this to diffraction.

(*b*) *Chrome-diopside.*—The mineral described under that name by Professor Lewis, and referred to by others as omphacite or sahlite. The individuals are sometimes about a quarter of an inch long. In thin slices it is a pale dullish green colour, inclining to olive; under the microscope, a pale sea-green, with a trace of pleochroism. It has one strongly marked cleavage, not however nearly so close as in ordinary diallage, and a second weaker, sometimes approximately at right angles to it.[1] On examining flakes, obtained by crushing, I find the strong cleavage to be clinopinacoïdal and the other probably basal, and obtain on a clinopinacoïd an extinction of 35° with a prism edge. It is in fact identical with the pyroxene described by Professor Lewis[2] as chrome-diopside. In it (though rarely) small rounded enclosures of a greenish mineral aggregate much blackened with opacite. I regard them as alteration products of a ferriferous olivine. This diopside, at the exterior and along cracks, is often converted into a minutely granular to fibrous mineral, which gives a 'dusty' aspect to that part of the crystal, when viewed with transmitted light, and a whitish-green one with reflected light. This often terminates in a minutely acicular fringe, piercing the original diopside. Its grains occasionally are a little larger, showing a cleavage, dull green in colour, fairly pleochroic, and having the extinction of hornblende. A process of secondary change, as in uralite, is no doubt indicated. Now and then a tiny film of brown mica occurs in this part or even in a crack in the diopside.

It is this alteration product which gives the mottled aspect mentioned above as visible to the unaided eye, so this is not indicative of a third important constituent in the original rock. In one of the slices the mica just named attains a larger size (about 0·03 in. across), has a fairly idiomorphic (hexagonal prism) outline, and is not restricted to the margin of the garnet. In this case it is generally associated with calcite,[3] which it tends to surround, and that in one place encloses a radiating acicular mineral (? a zeolite), in another the calcite, or some other carbonate, is mixed with a serpentinous material. Distinct granules of iron oxide are practically absent from the slices, though here and there it may be indicated by some opacite. I have not found spinel, or rutile, or zircon, or pseudobrookite. In fact, putting aside the diamonds, the rock in its unaltered condition was a coarsely holocrystalline mixture of chrome-diopside and garnet, with a few small enclosures of olivine; in other words, it was a variety of eclogite and of igneous origin.[4]

[1] One may give a general idea of their relative importance by comparing them to the columns and cross-joints in some basalts.

[2] Loc. cit., p. 21.

[3] From the facts I think it probably of secondary origin. It reminds me sometimes of the brown mica produced by contact metamorphism.

[4] I am, of course, aware that eclogite, in the past, has been regarded by some geologists as a metamorphic rock. Apart from the fact that several rocks once assigned to this class are now, with good reason, regarded as igneous, I have had

2. A fragment (probably about one-quarter) of a flattish ovoid boulder.—The two broken surfaces, which are nearly at right angles, measure 5 and 5½ in. roughly, and it is about 3¼ in. high. The rock very closely resembles the one just described, except that mica occurs rather oftener and in larger flakes; perhaps the garnets (here also not quite regularly distributed) are slightly more numerous. The outer surface is not quite so well preserved, though enough remains to show that it also has been smooth, and a few thin veins of a white mineral (calcite?) traverse the rock. On this surface, near the meeting of the two fractures, and exposed by the removal of a little material (i.e. it might originally have been just hidden), is a diamond (octahedron), apparently about 0·1in. in diameter. On one side it rests against a pyrope, the adjacent surface of which is incurved, the two minerals being parted by the dull green-coloured kelyphite rim of the latter, which is about 0·03 in. in thickness. Thin sections of this boulder correspond almost exactly with those from the other, the garnets showing precisely the same tints, though traces of a cleavage (roughly parallel throughout) are perceptible on close inspection, and are distinct under the microscope. In garnet such a structure commonly indicates pressure, and the general parallelism accords with this explanation, but the other constituents show no signs of crushing. The 'kelyphite' rims to the garnets are perhaps slightly broader and the brown mica passes into a green (chloritic?) mineral, and occupies cracks in the garnet a little more frequently, but as before the constituents tend to lie parallel rather than radially. One or two of the diopsides show fine oscillatory twinning. The cracks are occupied with calcite or some altered carbonate. There is no real difference between this eclogite and the last-named one.

ECLOGITE BOULDERS WITHOUT DIAMONDS.

3. Part of a boulder, which must have been about a foot in diameter.—In macroscopic aspect it presents a general resemblance to the rocks described above, with, however, the possibility of a second green constituent. This is not confirmed on microscopic examination. The rock consists, practically, of pyrope and diopside, as already described, except that negative crystals are rather unusually conspicuous in the latter. Into the details of these, as the point seems not to have any bearing on the present investigation, I do not purpose to enter.

4. A fragment, more irregular in form than the others, measures very roughly about 7 in. by 4¾ in. by 3½ in. It retains a good piece of the outer surface, which, though now a little corroded, was once smooth. The rock, which is rather decomposed and crumbly, consists chiefly of three minerals: garnet, not quite so large, paler and more pink in colour than the last-named; an emerald-green pyroxene, and a yellowish or greenish grey, platy to fibrous mineral, suggestive

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several opportunities of studying eclogite, and have no doubt as to its origin. Take *away the* alkali from a magma with the chemical composition of a diorite, and the *result would* be garnets in place of felspar, i.e., an eclogite.

of a second more altered pyroxene. In thin slices the paler and pinker tint of the garnet is very perceptible, as well as the tendency to a rude and generally parallel cleavage. But we find in it, under the microscope, a few microlithic enclosures, of an apparently colourless mineral, which occurs in long prisms crossed at about 70° by an occasional transverse cleavage, and extinguishing at an angle of about 26° with the longer edge. Many of the cracks exhibit slight decomposition, starting from them, and are sometimes occupied by calcite. The pyroxene, under the microscope, hardly differs from the one already described, except that the green tint is slightly richer and one or two crystals contain the small dark brown negative crystals, common in hypersthene and diallage. The dominant cleavage, as before, is along the clinopinacoïd.[1] The third mineral proves to be an altered enstatite, but I leave the details for the present as it is better preserved in another rock. A fourth constituent is also present, but more sparingly, viz., a pale-brown mica, only moderately pleochroic (phlogophite?). It occurs generally in plates, averaging about 0·1 in. long. The minerals appear to have formed in the following order: (*a*) garnet, (*b*) diopside, (*c*) mica, (*d*) enstatite. As before, iron oxides are very inconspicuous; there may be a grain or two (small) of serpentinised olivine. The marked presence of enstatite distinguishes this rock from the others, but it differs from the eulysites by the substitution of that mineral for olivine, and so links those rocks to the more ordinary eclogites. The occurrence of a little mica indicates the presence of a small amount of an alkali in the magma. If necessary we may name it newlandite, but personally I should prefer to call it an enstatite-eclogite, for I think the coinage of fresh titles more often a bane than a boon to science.

5. This boulder is almost perfect, except that the general flatness of one side indicates either traces of an old fracture or considerable loss by crumbling. The surface has been smooth, but it has suffered from unequal weathering of the minerals. Its girth, in three directions at right angles, is approximately 20½ in. by 19½ in. by 17½ in. It appears only to differ from the last-described in having its garnets a shade more purple, and in an approach to a banded structure; the diopside being rather more abundant in a middle zone, the garnet in one, the enstatite in the other of the outer zones. Being satisfied that it is merely a variety of the last-described rock, I have preferred to leave it as an intact boulder.

6. The next fragment, measuring about 3 in. by 2¼ in. by 2 in., and retaining part of its smooth outer surface, is labelled "found in the yellow ground of No. 2 mine[2] 50 feet deep." Though it is much more decomposed than the others, the purplish garnet, the emerald-green pyroxene, the altered enstatite (here very rotten), and a flake or two of phlogophite (?) are easily made out. It is

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[1] As noticed by Professor Lewis, ut suprà, p. 22, in the diopside the prism cleavage has practically disappeared, and a clinopinacoïdal cleavage replaces the orthopinacoïdal usual in diallage.

[2] The others come from another mine (No 1).

obviously a more decomposed specimen of the rock represented by the two preceding specimens.

7. The last of this group of specimens is a rock fragment,[1] measuring about 3½ in. by 2 in. in length and breadth, and slightly exceeding an inch in greatest thickness. Its outline is irregular, being determined by the fracture of the predominant diallage-like mineral. The crystals of this run large, an inch or more in length, breadth, and thickness. It is greyish-green in colour, having one dominant cleavage, with a sub-metallic lustre, and close subordinate cleavages, giving a somewhat fibrous aspect to that surface. Between these large crystalline lumps, numerous small, ill-defined garnets (pyrope) seem crowded, so as to form fairly continuous partings, generally hardly 0·1 inch in thickness. As the readiness with which the rather soft pyroxenic constituent split away made it improbable that a good slice could be cut, and I was reluctant to injure the specimen, I contented myself with detaching a few flakes of this constituent for microscopic work, since the determination of its identity was sufficient for my purpose. These show the mineral to have one easy cleavage and a rather fibrous structure; they give straight extinction parallel with this. As the usual rings and brushes can be seen on the face of easy cleavage, the mineral belongs to the bastite group. The same is true of the enstatite in boulder (4), though, as it is slightly more fibrous, and not in quite so good a condition, the optical picture is less distinct. Thus we may name the rock from which the present specimen has been broken, a garnet-bearing bastitite.

8. This specimen, said to be a fragment of a boulder, is very different from the rest. It is a compact greenish-grey rock containing enclosures, which give it the aspect, at first sight, of a pebbly mudstone. Microscopic examination shows it to be a compact felspathic diabase, with vesicles, which have been filled up with calcite, chlorites, and other secondary minerals (probably zeolites), but not to have any special interest. Its relations appear to be with the rocks occurring in a conglomerate which we shall mention in a later paragraph.

THE 'BLUE GROUND' AND ASSOCIATED ROCKS.

Two areas of diamantiferous rock are now being worked at the Newlands Mines. The shape of the one which supplied most of the specimens described in this paper is irregular, and, so far as I know, exceptional. Its outline at the surface may be roughly compared to a rounded triangle into the base of which the point of a rather short shuttle is thrust, the greatest breadth of the two being about equal. Exploratory workings at a depth of 300 feet show that the former area rather quickly narrows, and the latter terminates in clefts; the 'blue ground,' in fact, appears to fill a fissure, broadening in two places to vents which have been traced for some distance underground southwards from the principal mass of diamantiferous rock, as represented in the annexed section.

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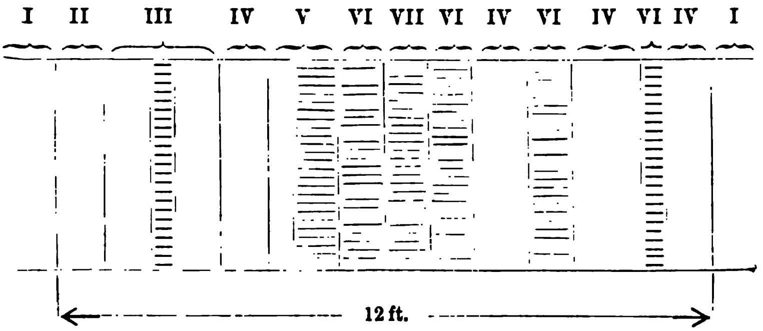
[1] I am informed that this was not part of a boulder, but came out of the 'blue *ground*' nearly in its present condition.



An igneous rock occurs on either side. It is compact, a greenish-grey in colour, not unlike some of the less acid Welsh felstones. Under the microscope it is found to be much affected by secondary mineral changes; the iron oxides alone being in good preservation. A few small crystals of decomposed felspar are scattered in a yet more decomposed matrix, of which the minor details are uninteresting. The rock may be classed with the compact, rather felspathic, diabases. These, farther to the south, turn off rather sharply to east and west.

In the interval, about 12 feet in width, between walls of this diabase, ribs of the 'blue' and a mudstone alternate, the thickest one of the former being from 3 to 4 feet in width, and the inner part of it is in better preservation than the outer. Specimens have been examined from the heart of the mass (vii), a part outside it (vi), and the exterior portion (v). The first (vii) in texture, hardness, and colour reminds me a little of the dark serpentine found north of Cadgwith, in Cornwall. In this matrix roundish spots occur, some darker than it, others a yellow-green colour, besides a few angular whitish spots. The block is traversed by two or three thin calcareous veins. Specimen (vi), while generally similar, is more decomposed, and apparently contains some fragments of shale. Specimen (v) has a stratified aspect, being a dull grey, faintly mottled rock, with streaky, dark, rather carbonaceous-looking bands; the origin being doubtful, till it is seen under the microscope. A fourth specimen (iii) shows the mudstone traversed by a vein of rather pale-coloured decomposed 'blue,' not exceeding an inch in thickness. A fifth (ii) is from near the diabase on the western side, a dark compact rock, faintly mottled, here and there presenting a slight resemblance to a 'blue' traversed by thin veins of a carbonate; and sixth (iv) from a like position on the opposite side is a generally similar rock, but with wider veins filled with more coarsely crystalline calcite. The last specimen represents the 'blue' in the 'neck,' a few yards to the north and at the same level (300 feet). This, inferior in preservation to the first-named, includes numerous rounded fragments a little darker than the matrix, with others, angular to sub-angular, some also darker and some lighter than it.

A brief summary of the results of microscopic examination may suffice, as these rocks do not materially differ from specimens obtained in the De Beers Mine, of which I have published a full account [1]

The matrix is a mixture, in slightly variable quantities, of granules of calcite or dolomite, serpentine, pyroxene, and iron oxides, in which occur flakes with fairly idiomorphic outlines of a warm-brown mica, moderately pleochroic, corresponding with that described [2] in one or two specimens from De Beers Mine. The prisms are about 0·002 in. in diameter, and sometimes nearly as thick. This mica, which, as stated in a former paper, I consider a secondary product, occurs abundantly in all the specimens, but in that from the interior (on the whole the best preserved rock) it is locally assuming a green colour, no doubt by hydration. In the specimens from the thick rib, the one last named contains mineral grains and rock fragments, except for a few flakes of the usual mica. The former are a mixture of two fibrous minerals, the larger part corresponding with actinolite; the rest, giving lower polarisation tints, may be serpentine. This fact, and structures suggestive of the former presence of a cleavage more regular than that of olivine, make it more probable that diopside was the original mineral. Though iron oxide is present in specks and rods (especially in the worse preserved specimen), this occurs either in the outer part, or as though it had been deposited along cleavage planes. In the thin rib of 'blue' (iii), some of the grains are composed partly of a fibrous mineral, as above described, and partly of a clear one, which often affords rather rich polarisation tints, and presents some resemblance to quartz. Its precise nature is difficult to determine, owing to the absence of distinctive characters, but I believe it to be of secondary origin. Rock fragments are not common in the first (interior) specimen (vii); one, however, is probably an altered shale, and another possibly a limestone. This is bordered by a pale, pyroxenic mineral piercing into the grains of calcite. In the second specimen (vi) fragments are rather common; among them are those of diabase, ranging from fine to coarse, one specimen of the latter, originally, perhaps, an inch in diameter, showing an ophitic structure; felspar and augite both being rather altered, seemingly by infiltration, and one small fragment resembles a subcrystalline limestone. Specimen (v) does not materially differ, but seems to contain more carbonate than the others. The dark streaking is due to grains of iron oxide or serpentine with much opacite; rock fragments few and small. Specimen (iii) from the thin vein contains a few very small rock fragments, mudstone or shale, more or less altered, possibly also a compact diabase. The 'country rock' is a mudstone, consisting of small chips of quartz and felspar, variable in size, embedded in a dusty matrix, including a carbonate, which is more abundant within about a fiftieth of an inch from the junction. This part is slightly stained, but I was unable to detect any signs of contact metamorphism. Specimens (ii) and (iv) are generally similar, but the former contains some small rounded bits of varieties of diabase, and one may represent a crystalline limestone. The veins are filled with calcite and other secondary products, and are bordered by a very thin film of a brown micaceous mineral, like that described as often permeating the 'blue.' Both specimens suggest micromineralogical changes, such as might be produced by the passage of hot water.

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[1] Geol. Mag., 1895, p. 492; and 1897, p. 448.

[2] Geol. Mag., 1897, pp. 450, 451.

Other specimens of the sedimentary rock in the immediate neighbourhood of the blue have been forwarded to me by Mr. Trubenbach; one, from the adit on the southern side of the section mentioned above, is a grey mudstone, containing a flattish rectangular pebble, of a dark-green compact rock. Two others are from No. 2 mine, or about 700 yards to the south-west. One, struck in the shaft at a depth of 200 feet, is a conglomerate, composed of well-rounded rock fragments, with some scattered grains of quartz. Each of the former is bordered by a zone of a crystalline carbonate (impure calcite), and the interstices are filled, sometimes by a clearer variety of the same, but more often by some minutely granular secondary product. Of the rock fragments, one is a subcrystalline dolomitic limestone; two, perhaps, are chalcedony; the remainder are igneous; the majority being varieties of diabase, sometimes rather decomposed; the rest trachytes, mainly andesites. Their general aspect and the not unfrequent presence of vesicles (now filled with viridite) suggest that they have been furnished by lava-flows. Another specimen, obtained in the same working at a depth of 400 feet, is a rather felspathic diabase, not unlike one of the varieties in the conglomerate. It is a good deal decomposed, is not improbably from a lava-flow, but does not call for a minute description.

Conclusion.

Thus the diamond has been traced up to an igneous rock. The 'blue ground' is not the birthplace either of it or of the garnets, pyroxenes, olivine, and other minerals, more or less fragmental, which it incorporates. The diamond is a constituent of the eclogite, just as much as a zircon may be a constituent of a granite or a syenite. Its regular form suggests not only that it was the first mineral to crystallise in the magma, but also a further possibility. Though the occurrence of diamonds in rocks with a high percentage of silica (itacolumite, granite, etc.) has been asserted, the statement needs corroboration. This form of crystallised carbon hitherto has been found only in meteoric iron (Canyon Diablo), and has been produced artificially by Moissan and others with the same metal as matrix. But in eclogite the silica percentage is at least as high as in dolerite; hence it is difficult to understand how so small an amount of carbon escaped oxidation. I had always expected that a peridotite (as supposed by Professor Lewis), if not a material yet more basic, would prove to be the birthplace of the diamond. Can it possibly be a derivative mineral, even in the eclogite? Had it already crystallised out of a more basic magma,[1] which, however, was still molten, when one more acid was injected, and the mixture became such as to form eclogite? But I content myself with indicating a difficulty, and suggesting a possibility; the fact itself is indisputable: that the diamond occurs, though rather sporadically, as a constituent of an eclogite, which rock, according to the ordinary rules of inference, must be regarded as its birthplace.

This discovery closes another controversy, viz., that concerning the nature of the 'Hard blue' of the miners (Kimberlite of Professor Lewis), in which the diamond is usually found. The boulders described in this paper are truly water-worn. The idea that they have been rounded by a sort of 'cup and ball' game played by a volcano may be dismissed as practically impossible. Any such process would take a long time, but the absence of true scoria implies that the explosive phase was a brief one. They resemble stones which have travelled for several miles down a mountain torrent, and must have been derived from a coarse conglomerate, manufactured by either a strong stream or the waves of a sea from fragments obtained from more ancient crystalline rocks.[2] The 'washings,'[3] a parcel of which I received from Mr. Trubenbach, also show that the boulders are really water-worn. Besides two unworn pieces of pyrite and a rough bit of eclogite, about three-quarters of an inch in diameter, the pyroxenic constituent of which was a bright emerald green (? smaragdite), I find part of a subangular fragment of chrome-diopside associated with two or three flakes of the usual mica, a well-rounded garnet fully 0·6 inch across, and half a well-worn pebble of eclogite, about one inch long and half an inch thick. The rounded water-worn look of the great majority of the smaller constituents (chiefly garnets and pyroxenes), about the size of hemp-seed, is very obvious. I had suspected some of the grains washings from the De Beers Mine to have been similarly treated; but here it is indubitable, indeed many of the dark green specimens are so smooth outside that they could only be identified after fracture. The ordinary diopside can, however, be recognised, with some of a clearer and brighter green. Most of the garnets are pyropes, but a few resemble essonite. I find also some grains of iron oxide and of vein quartz. Thus, the presence of water-worn fragments, large and small, in considerable abundance, shows the 'blue ground' to be a true breccia, produced by the destruction of various rocks (some of them crystalline, others sedimentary, but occasionally including water-worn boulders of the former) — i.e., a result of shattering explosions, followed by solfataric action. Hence the name Kimberlite must disappear from the list of the peridotites, and even from petrological literature, unless it be retained for this remarkable type of breccia.

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[1] This, however, cannot have been very rich in iron, because diopside does not contain much of that constituent.

[2] As these eclogites are very coarsely crystalline, we are justified in assuming they were once deep-seated rocks, and so much more ancient than the date of the conglomerate. To prevent any misunderstanding I may repeat that the matrix from which these boulders were taken (at various depths, from nearly 100 to about 300 feet) cannot be any alluvial deposit, but is the typical 'blue ground,' practically identical with that in the Kimberley mines.

[3] The name is given to the mineral residue left after washing away the decomposed *matrix of* the 'blue ground.'

Boulders, such as we have described, might be expected to occur at the base of the sedimentary series, in proximity to a crystalline loor. The Karoo beds in South Africa, as is well known, are underlain in many places by a coarse conglomerate of considerable hickness and great extent, called the Dwyka conglomerate, which s supposed to be Permian or Permo-Carboniferous in age. It crops out from beneath the Karoo beds at no great distance from the diamond-bearing district, and very probably extends beneath it. f this deposit has supplied the boulders, the date of the genesis of the diamond is carried back, at the very least, to Palæozoic ages, and possibly to a still earlier era in the earth's history.

REVIEWS.

.—THEORY OF THE EARTH, WITH PROOFS AND ILLUSTRATIONS. In Four Parts. By JAMES HUTTON, M.D., F.R.S.E. Vol. III, Edited by Sir ARCHIBALD GEIKIE, D.C.L., F.R.S. 8vo; pp. xvi, 278, with Index to Vols. I and II. London, 1899. Published by the Geological Society, Burlington House, London. Price 3s. 6d.

IN the annals of Geology, Hutton's "Theory of the Earth" ranks as one of the principal classics, and if this original work has been to some extent eclipsed by Playfair's lucid "Illustrations" of t, the fame of the author and his influence on the progress of geology have thereby been greatly enhanced. Of the four parts which the "Theory of the Earth" was planned to comprise, two only were published (in separate volumes) in Edinburgh in 1795, wo years before the death of the author. An incomplete MS. of he third volume, intended to embrace the third and fourth parts of the work, has long been in the possession of the Geological Society. This MS. commences with Chapter IV; the efforts to discover the earlier portion having proved unsuccessful. It is remarked by the Editor that although there is reason to believe that the MS. of Vol. III was nearly ready for the printer at the time when the other wo volumes were published, yet it is possible that the want of drawings to illustrate the text may have caused the delay. The six chapters now published deal mainly with Hutton's views regarding he origin of granite; they include narratives of his excursions into different parts of Scotland, notably to Glen Tilt, to Galloway, and o the Isle of Arran. As the Editor points out, Hutton's Essay on Arran "is a masterpiece of acute observation and luminous generalization. Had it been published in his lifetime, it would have placed him at once as high in the ranks of field-geologists as he admittedly stood among those of the speculative writers of his time."

We may quote a few passages in reference to the visit to Arran which was made in 1786:—

"In setting out upon that expedition, I had but one object in view; this was the nature of the granite, and the connection of it with the contiguous strata. . . . Our head-quarters were at Brodowick [Brodick], and our first object was to examine around the mountain of Goatfield for the connection of the granite with the strata or surrounding bodies. This, however, cost us a great deal of trouble to accomplish. . . . After making some other fruitless attempts, I set out on horseback for Loch Ranza; with a view to investigate the same object by the way, as well as to examine the north end of the island, where I knew the coal and slate were worked near the shore. Upon this road I observed that the North Sanox river, which I had crossed in entering the schistus district to the north, runs nearly in the junction of the schistus and the granite mountains, the characters of which are very distinguishable to the view. I then went forward, but in returning I quitted my horse, and went over the mosses and muir towards the heads of that North Sanox river which there divides into two streams. Here I had the satisfaction to find the immediate junction of the schistus with the granite, in the solid rock, exposed perfectly to view, and that in both of these rivulets, a little way above their junction. Nothing can be more evident than that here the schistus had been broken and invaded by the granite; as in this place the regular stratification of the vertical schistus is broken obliquely by the other rock, and parts of the schistus involved or almost insulated in the mass of granite, which from this junction enters and traverses the body of the schistus in little veins terminating in capillaries."

This and many other passages show the care and discrimination with which Hutton pursued his observations, and the remarkable insight he showed in determining the geological structure. In his visit to Arran, as in his "Journey to the North Alpine part of Scotland," in 1785, the question before him was how far the granite "is to be considered as a primary mass in relation to the alpine schistus; in that case, fragments of the granite might be found included in the schistus, but none of the schistus in the granite."

In elucidation of the text the Editor has inserted numerous explanatory notes, which are full of interest in themselves, and will greatly aid the reader. Moreover, he has most effectively supplied the place of the missing drawings by original pictorial views and drawings taken by himself in Arran while specially following Hutton's route with his description in hand. Other illustrations borrowed from publications by Macculloch and the Geological Survey are introduced to make clear particular features described in the work. The Editor has furnished an index to the volume, and also a separate index to vols. i and ii—a contribution which will be much appreciated by the happy possessors of those volumes.

We may heartily congratulate Sir Archibald Geikie and the

Geological Society on the publication of this work, which is not only a tribute to the memory of one of the Early Fathers of Geology, but one which will be read and appreciated by all interested in the history of the science.

II.—CAPE OF GOOD HOPE: ANNUAL REPORT OF THE GEOLOGICAL COMMISSION FOR 1897.

THE main features of the report for 1897 are the accompanying map and sections. The map is on a reduced scale of 12·62 English statute miles to one inch, and shows the geology of the area stretching from the west coast eastward to the Gamka River, and from the Zwarteberg Mountains on the north to some distance south of the Langebergen. The map is clearly printed in colours, the major faults being successfully represented by a narrow uncoloured band. The structure of the area is illustrated by five horizontal sections drawn across the intervening districts situated between Worcester on the west and Ladismith on the east.

The report itself is marked by commendable caution, there being an entire absence of the highly coloured descriptions so usual in African geological literature.

The Commission is to be congratulated on the amount of work done, and the interest and importance of the results obtained. Especially worthy of praise is the adherence to a plain statement of facts in place of building up, on insufficient data, elaborate and fascinating theories.

The succession established by Bain and Dunn is in the main adhered to, the formations in descending order being given as follows:—

Conglomerate, Gravels, Sands, and Limestone.
Ecca Beds.
Dwyka Series.
Witteberg Beds.
Bokkeveld Beds.
Table Mountain Sandstone.
(Marked unconformity.)
Malmesbury Beds.
Granite intrusive in Malmesbury Beds.

The Malmesbury Beds cover wide areas round Hopefield and Malmesbury, and are represented as forming a narrow strip north of the great dislocation known as the Worcester-Robertson Fault, between Tulbagh on the north-west and Swellendam on the south-east, and also a small triangular patch east of Ladismith and south of the Zwarteberg. One of the greatest alterations from the excellent map of Mr. Dunn is the withdrawal of the Malmesbury Beds from the Caledon district, and the insertion of strata of Bokkeveld age in their place, thus returning to the mapping of A. G. Bain. The Malmesbury are considered to be the oldest rocks seen at the Cape, the Namaqualand schists and gneiss of Mr. Dunn and other writers on South African stratigraphy not being recognized as separate divisions.

The Malmesbury Beds consist of micaceous slates, fine compact quartzites, phyllites, and mica schists, as predominant rocks, with bands of crystalline limestone and beds of sheared conglomerate. Ottrelite schists are not uncommon in the series from the Hex River to Swellendam. The intrusive rocks are granite, quartz-porphyry, and diabase, considerable areas being shown on the map between St. Helena Bay and Malmesbury and around Paarl and Stellenbosch. The granite is a coarsely porphyritic biotite granite; segregation veins are numerous and form considerable masses. The granite often shows distinct evidence of shearing.

Between the Malmesbury Beds and the overlying rocks a great unconformity is everywhere noticed. The Table Mountain Sandstone Series on Table Mountain, though lying flat, is described as having been subjected to considerable earth movement, as shown by the presence of vertical cleavage and occasional shearing. In the mountains beyond Mitchells Pass and Hex River, and in the Kloofs and Passes of the Zwarteberg and Langeberg, magnificent examples of the twisting and curving to which the Table Mountain Sandstone has been subjected are seen. The Table Mountain Sandstone consists of coarse sandstones and quartzites, with subordinate bands of shale; no fossils have been found.

The Bokkeveld Beds, which conformably succeed the Table Mountain Sandstone, consist of sandstones and shales, but the latter play a much more important part than in the Table Mountain Sandstone Series. Many fossils of Devonian facies are found.

The Bokkeveld Beds pass up into another sandstone and shale group with bands of quartzite, called the Witteberg Beds in the report. These correspond to the Zwarteberg Quartzite Series of other writers; the alteration of name being necessary as the Zwarteberg Mountains are found by Mr. Rogers to consist of Table Mountain Sandstone. The only fossils found in the Witteberg group are plant remains and the curious markings called *Spirophyton*, of doubtful organic origin, but said to be very characteristic of this group.

The Table Mountain Sandstone, Bokkeveld and Witteberg Series, are sometimes grouped together as the Cape Formation. The thickness cannot be estimated, but the three groups form a conformable series of quartzites, sandstones, and shales, several thousand feet thick.

The Dwyka Series and Ecca Beds are described as conformable to the Witteberg Group. This is an important result, as the Dwyka has been generally described as unconformable to the Witteberg Group. Considerable interest is also attached to the discovery by the Commission of strata of Dwyka and Ecca age around Worcester, to the south of the Worcester-Robertson fault, showing the further extension southwards of these beds than was hitherto expected. The presence of *Gangamopteris* in the beds at Worcester places this discovery beyond dispute.

Some interesting facts, throwing light on the origin of the Dwyka, have been obtained by the Commission. The most important is the discovery of undoubted scratched stones, resembling true glaciated pebbles; a large boulder of granite, 10 feet by 8 feet in section, was found lying in the Dwyka in the poort, where the Witteberg River cuts across the Dwyka ridge, south of Lainsberg. The pebbles consist of several varieties of granite, several kinds of more basic igneous rocks, sandstones, quartzites, argillaceous and calcareous rocks, and vein quartz. There are distinct bedding planes in the rock, and the bedding is everywhere conformable to that of the quartzites of the underlying Witteberg Group.

Extensive superficial deposits, probably in most cases of recent origin, are mapped in several localities. The most interesting of these are the sand dunes on the shores of False and Table Bays and over large areas in the Malmesbury district. In some places the entire mass of the dunes has been converted into a more or less compact sandstone or limestone, that at Saldanha Bay being quarried as a building stone. These deposits have sometimes been taken as of Tertiary age, but the occurrence in them of recent shells, often of terrestrial genera mingled with bones of rhinoceros, elephant, etc., points to their recent origin. WALCOT GIBSON.

MEMOIRS OF THE GEOLOGICAL SURVEY.

III.—THE WATER SUPPLY OF SUSSEX FROM UNDERGROUND SOURCES. By WILLIAM WHITAKER, F.R.S., and CLEMENT REID, F.L.S., F.G.S. 8vo; pp. iv, 123. (London: printed for H.M. Stationery Office, 1899. Price 3s.)

MR. WHITAKER, more than any other member of the Geological Survey, devoted attention during his long official career to the important applications of geology to questions of water supply. Now that he has retired from the Survey he has been good enough (as the Director-General points out) to assist Mr. Reid in arranging the numerous records of well-sections, which form the bulk of the present Memoir. The work, in fact, contains all information which could be obtained concerning the well-sinkings and borings in Sussex, with analyses of many of the waters, and a brief introductory account of the geological formations met with in the county. It cannot fail to be of great practical value.

DESCRIPTIVE MONOGRAPH OF THE AMMONITE GENUS *PERISPHINCTES.*

IV.—MONOGRAPHISCHE BESCHREIBUNG DER AMMONITENGATTUNG PERISPHINCTES. By Dr. JOS. VON SIEMIRADZKI. Palæontographica, Bd. xlv (1899), pp. 69–352, pls. xx–xxvii.

THE Ammonite genus *Perisphinctes*, founded by Waagen in 1869 as a subgenus of *Stephanoceras*, and shortly afterwards raised to generic rank by Neumayr, Zittel, and Waagen himself, has now become so large that any attempt to classify the forms which have been included in it is not only a difficult task, but entails a vast amount of labour and research. For the present monograph of this very extensive genus the author therefore deserves our best thanks. He tells us that in its preparation he has consulted 128 separate publications in German, French, English, Italian, Spanish, Polish, and Russian; and that besides his own collection, which contains several hundred examples of the genus, he has examined the collections of several private individuals, as well as those of various Continental museums. In some cases in which the author was unable to see the type-specimens he obtained plaster casts of them, in order to gain a correct idea of the species. One great difficulty in dealing with this genus is caused by the very vague manner in which several specific names, such as *biplex*, *plicatilis*, *polyplocus*, and *polygyratus*, have been used, due in some cases to the inadequate description or figure of the type-specimen. The author concludes that a precise limitation of the genus from allied genera is not possible, and that its limits must be drawn somewhat artificially. The author devotes a short but interesting chapter to the morphology of the shell, and then proceeds to the classification of the genus, in which he recognizes about 367 species, only a few of which are new. His investigations lead him to divide the genus into six sections, which he groups into five subgenera, thus:—I, *Grossouvria*, n. subgen. (including II, *Biplices*, Sutner); III, *Ataxioceras*, Fontannes; IV, *Perisphinctes*, s. str.; V, *Procerites*, n. subgen.; and VI, *Choffatia*, n. subgen. These are divided into 'Mutationsreihe,' or developmental series, and these again into 'Formenreihe,' or groups of contemporaneous species. The author gives a description of each species, lateral views of the new forms and of some others are given on the eight photographic plates accompanying the work, an outline of the transverse section of the whorl and a drawing of the suture-line of many of the species being given in the illustrations which are included in the text. There is an index to the work, but this appears to be somewhat incomplete. G. C. C.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 10, 1899.—W. Whitaker, B.A., F.R.S., President in the Chair. The following communications were read:—

1. "The Geology of the Davos District." By A. Vaughan Jennings, Esq., F.L.S., F.G.S.

Alpine geology has attracted many workers since the date of Professor Theobald's classic memoir on the district of which Davos forms part, and new principles of interpretation have been established. The author has more especially studied (*a*) the age of certain rocks formerly classed as 'Bündner Schiefer,' but distinct from the grey shales variously regarded as of Jurassic or Tertiary age; (*b*) the origin and date of the serpentine near the Davoser See; and (*c*) the tectonic structure of the district. The following rock-groups occur in the neighbourhood treated of:—(1) Gneisses and crystalline schists more ancient than any of the others; (2) the Cassana Schiefer, a name applied to a variable group of rocks, ranging from true schists to dark shaly rocks, apparently less crystalline and more recent than the above-named, but older than (3) the Verrucano, a conglomerate or grit with occasional mudstones, sometimes associated with a quartz-porphyry, the last representing the well-known rock in the Botzen district; (4) the 'Mittelbildung' of Theobald, strata intermediate between the Verrucano and the Haupt-Dolomit, very variable in lithological character, in which sometimes the Arlberg Kalk and Virgloria Kalk can be identified, and typical rauchwacke, which occurs at two levels. Above this comes (5) Haupt-Dolomit of the usual character, followed in places by beds (6) of Rhætic age. Of more local occurrence are (i) serpentine, a large mountainous mass on the western side of the Davoser See, with a narrow extension northward and southward for a considerable distance; (ii) red and green schistose rocks; (iii) radiolarian chert; (iv) breccias; (v) the so-called talc-granite; and (vi) diabase, among which, at Arosa, is a variolite. The schistose rocks (ii) are common in the neighbourhood of the East Alpine serpentines, and in this region the latter rock passes down on the western side into ophicalcites, which are followed by a confused mass of layers of serpentine alternating with reddish calcareous or argillaceous bands. These the author considers to indicate a physical condition rather than a geological horizon. With the red and green schistose rocks, which he refers to the Mittelbildung, radiolarian cherts are associated. These have been examined by Dr. G. J. Hinde, who states that the radiolaria are not sufficiently well preserved for specific identification, but have rather a Jurassic facies, though they also resemble radiolaria, described by Professor Parona from Cesara, which that author regards as at any rate not newer than Lower Trias.

The author discusses at length the physical structure of the district. The general trend of the Davos Valley is rather oblique to that of the greater rock-masses, which, however, is somewhat irregular. He shows that these (which have a general dip towards the south and east) form three great acute and rudely parallel overfolds, the westernmost being the most complicated; of this fold the serpentine forms a part. It is more recent than the crystalline schists and the Casanna Schiefer, and is associated with the red and green schistose rocks already mentioned, in a way which he considers indicative of intrusion; but it nowhere cuts the Haupt-Dolomit. Accordingly he considers it to be later than the Verrucano, and not earlier than the middle part of the Trias. Certain crystalline breccias occur in the neighbourhood of the serpentines; these the author considers to be due to earth-movement, and he goes on to give reasons for regarding them as the equivalent of the Casanna Schiefer of other localities. There is, in his opinion, no evidence of the presence of post-Jurassic strata such as Professor Steinmann believes to exist.

2. "Contributions to the Geological Study of County Waterford. Part I, § 1: The Lower Palæozoic Bedded Rocks of the Coast." By F. R. Cowper Reed, Esq., M.A., F.G.S.

This paper opens with an account of the previous publications on the geology of the district, and then goes on to describe the sections exposed along the coast at the following localities:—Raheen and Newtown Head, Tramore Bay, Garrarus and Kilfarrasy, Annestown and Dunabrattin, Knockmahon, Ballydouane Bay, and Killelton Cove to Ballyvoyle. These sections expose shales and limestones with abundance of igneous rocks partly interbedded, but mainly intrusive; and the author is able to make the following succession of rocks, tabulated in descending order:—

4. Raheen Series. Mudstones, slates, felsites and tuffs, and fossiliferous shales.
3. Carrigaghalia Series. Graptolitic shales, thin flags, cherts, tuffs, and felsites.
2. Tramore Limestone Series. Divided into three stages.
1. Tramore Slates. Calcareous and argillaceous slates.

Nos. 3 and 4 are represented by barren limestones at Dunabrattin, and 1, 2, and 3 by felsites and tuffs at Newtown Head.

The palæontological portion of the paper gives the previously published lists of fossils, including those recorded by McCoy in his "Synopsis." The author has examined and re-identified all McCoy's specimens. A further list gives the peculiar species hitherto found in the British Islands only in Waterford. The chief species are then dealt with in detail: a number of new species of trilobites and brachiopods, and one new genus of trilobites, being described.

Petrological notes of the interbedded igneous rocks are next given. These are lavas and tuffs, all acid in composition and possessing from 75 to 78 per cent. of silica. The groundmass is generally cryptocrystalline, but spherulitic, granophyric, nodular, perlitic, and fluxion structures are common. Phenocrysts do not appear to be common; plagioclase-felspar predominates over quartz, and that over orthoclase, but felspar-microlites are of frequent occurrence.

The author has previously compared the Tramore Limestones with the Balcletchie Shales of Scotland; but he now considers that they mainly represent beds on a lower horizon, as they are overlain by rocks displaying a Glenkiln facies. The fauna of the Limestones themselves presents so peculiar a facies that they have often been considered to be of Bala age. Although the graptolites of the Carrigaghalia Series correspond with those of the *Dicranograptus*-shales of South Wales, the underlying (Tramore) limestone has not the fauna of the Llandeilo Limestone, but corresponds more nearly with the *Orthoceras*-limestone of Sweden. The characteristic genera *Porambonites*, *Amphion*, *Echinosphæra*, and *Glyptocystis* are common to the Tramore Limestone, the *Orthoceras*-limestone, and the corresponding Echinospherite Limestone and 'Vaginatenkalk' of Russia, while there is also a likeness in the abundance of *Pterygometopus* in Russia and Waterford. A list of common and allied or representative species is given in the paper. Stage 1 of the Tramore Limestone may include beds as low as or lower than the ***Megalaspis gigas*** zone $= B_3$ Vaginatenkalk of Russia; Stage 2 may especially be compared with the Echinospherite Limestone; and Stage 3 probably partly represents the upper part of this Limestone and the lower part of the overlying Kuckers Shales C_2. The *Didymograptus*-shales have not yet been identified, though it is just possible that the Tramore Slates may represent them.

The Raheen Shales of Newtown Head contain *Orthis argentea* in abundance, and may be compared with the *O. argentea* zone, which in South Wales comes above the *Dicranograptus*-shales. But these beds also contain species peculiar to them, and others with a Scandinavian or Russian affinity; and the shales may be compared with the upper part of Tullberg's Series E of the Middle Graptolite Shales. The occurrence of this East European Lower Ordovician fauna in the western part of the British Isles is of great interest with reference to questions of ancient bio-geographical provinces; and it seems to require that the coastline along which this littoral fauna flourished stretched round from Scandinavia so as to approach the south-eastern corner of Ireland, while deeper-water conditions coexisted in Wales and England. Volcanic activity began about the period of the accumulation of the *Dicranograptus*-shales near Tramore, and possibly earlier at Raheen, where it also continued till after the *Orthis argentea* beds had been deposited.

II.—May 24, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

The President called attention to the issue of vol. iii of Hutton's "Theory of the Earth," and said that the thanks of the Fellows were due to Sir A. Geikie for having edited and annotated most carefully this work. The volume was printed from a previously unpublished manuscript which had been for many years in the possession of the Society: its contents were extremely interesting, and it supplemented the previous volumes by the inclusion of an index to the whole of the work, prepared by Sir A. Geikie.

Professor Seeley exhibited a cast from a footprint obtained by Mr. H. C. Beasley from the Trias at Stourton. The impression is about 1½ inch long, and nearly as wide. The cast has been treated by oblique illumination, so as to display its osteological structure by means of the shadows thus thrown. All the claws are directed outward, as in a burrowing animal. The form of the foot resembles that of a monotreme mammal rather than that of any existing reptile. There appears to be a slender pre-pollex including three bones. The only other example of this structure in the Trias is in the Theriodont reptile *Theriodesmus*, in which it is less definite. This character may add to the interest of other footprints from Stourton, which in the form of the foot approximate to Anomodont reptiles from the Karoo Beds of Cape Colony.

The following communications were read:—

1. "On the Distal End of a Mammalian Humerus from Tonbridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

The bone described in this communication was found in 1898 by Mr. Anderson on the bank of the River Medway, near Tonbridge. It was seen projecting from reconstructed rock which contained fragments of flints among other materials. Traces of matrix at the distal end show that the specimen has been derived from quartz-sand bound together with limonite, such as might occur in the Hastings Sand, Wealden Clay, or Lower Greensand. Conditions of mineral structure and osteological character incline the author to believe that the bone was originally contained in the Wealden Clay. The fossil is 4 inches long, and indicates a humerus which may have been 6 inches in length when perfect, as large as that of a wolf but smaller than that of a bloodhound. The form of the shaft precludes any comparison with the carnivora, and indicates a resemblance to ungulate types. When the bone is held vertically and seen from the front, the condyles are oblique—a character not observed in any other animal. The weight of evidence appears to incline towards reference of the fossil to the Artiodactyla, but it probably indicates a new family type.

2. "On Evidence of a Bird from the Wealden Beds of Ansty Lane, near Cuckfield." By Prof. H. G. Seeley, F.R.S., F.G.S.

A fragment of bone found, by Mr. Neville Jones, a member of the London Geological Field Class, embedded in sandstone was identified by the author as probably the distal end of the femur of a bird. The external condyle is not only larger and deeper than the inner, but is more prolonged distally—perhaps the most distinctive avian character of the bone. *Colymbus* is the only existing bird to which the fossil makes any approximation, but the resemblance is distant and not suggestive of near affinity, and it is interesting that the Cretaceous birds show so marked an affinity with that type. The resemblances of the Dinosaurian and Crocodilian femora with this type are such that almost every individual feature of the bone can be paralleled in some fossil referable to these groups, but there are no British dinosaurs of so small a size or possessing some of the marked features shown by this bone.

3. "Notes on the Rhyolites of the Hauraki Goldfields (New Zealand)." By James Park, Esq., F.G.S., and Frank Rutley, Esq., F.G.S.; with Analyses by Philip Holland, Esq., F.I.C., F.C.S.

Part i of this paper, by Mr. J. Park, gives a description of the rhyolites as seen in the field. After a rest from volcanic action during the Secondary Period, the Tertiary eruptions burst forth and were more widespread than those of recent times. In the Hauraki Peninsula the basement Palæozoic rocks are covered by richly fossiliferous marly clays and limestone of Lower Eocene age, and these by a vast accumulation of andesitic lavas and tuffs, in places 3,000 feet thick. These andesites are the gold-bearing rocks of the district, and they are succeeded by rhyolitic lavas and ashes. Both andesites and rhyolites were influenced by solfataric action, resulting in siliceous deposits rich in gold and silver. The *rhyolites* rest on rocks probably of Upper Miocene age, and are followed by Pleistocene and recent deposits; so that they probably range from older to newer Pliocene in date.

Part ii contains the observations of Mr. Rutley on the petrology of the rhyolites. The rocks present occasional occurrences of perlicity, and the lithoidal types sometimes owe their characters to subsequent devitrification, sometimes to the effect of cooling on or immediately after eruption. Reheating has at times reduced the felspars to the condition of felspar-glass. Although plagioclase-felspar is common, the analyses indicate that the series must be retained with the rhyolites, it being quite possible that some of these minerals may have been derived from the andesites. In the rocks of Omahu, branching spherulites of microfelsitic material are described in detail, the microfelsitic substance being an imperfectly devitrified glass of fibrous aspect, the fibres having an imperfectly margaritic or longulitic character. Among the fibres often lie filmy scales which may possibly be tridymite. The term microfelsite is considered worthy of retention, as it denotes a phase of devitrification not adequately expressed by any other name: "while its abandonment would produce a gap which could only be bridged by much circumlocution."

4. "On the Progressive Metamorphism of some Dalradian Sediments in the region of Loch Awe." By J. B. Hill, Esq., R.N. (Communicated by Sir A. Geikie, D.Sc., LL.D., F.R.S., F.G.S.)

The region under discussion contains two principal series of rocks, passing one into another without a break, and conveniently referred to the Dalradian System:—(1) The Ardrishaig Series (phyllites and fine-grained quartzites). (2) The Loch Awe Series (black slates, limestones, grits, and quartzites). The latter series lies in a gentle trough of the former. Even in their most altered state, the clastic nature of the rocks of the Loch Awe Series is apparent. Both Series are pierced by innumerable intrusive sills of epidiorite, hornblende-schist, and chlorite-schist, modified diorites and gabbros, which effect contact-metamorphism in the bordering sediments. Intrusive rocks of post-schistose date also occur, like the Glenfyn granite, the granite of Ben Cruachan, and smaller masses of granite, monzonite, hyperite, ultrabasic rocks, quartz-porphyries, felspar-porphyries, porphyrites, and lamprophyres; these are in their turn cut by dolerite and basalt-dykes. All these rocks exhibit progressive metamorphism when traced towards the north-east and towards the Central Highlands, a character best seen in the loop formed by the rocks near the head of Loch Awe. The Ardrishaig phyllites, almost clay-slates, pass into mica-schists of the normal Central Highland types. The Loch Awe limestones become epidotic, and contain biotite, garnet, and actinolite, the crystals of the last mineral being sometimes 1 inch long. The black slates acquire garnets and actinolite. The grits and quartzites become granulitic, and pass into gneissose rocks with black and white mica, garnets, actinolite, tourmaline, epidote, and red felspar; they pass into the quartzites, gneissose flagstones, and biotite-gneisses of the Central Highlands, without anywhere reverting to the approximately unaltered condition which they exhibit to the south-west. The sills become granulitized and partly recrystallized, with biotite and garnets.

These rocks, which occur on the strike of the Central Highland schists, are linked with the latter by the persistence of the Loch Awe rock-types, including the boulder-bed, which is regarded as having a definite stratigraphical position. It is true that when traced along the strike the metamorphism increases rapidly towards such granite-masses as that of Ben Cruachan, but the same type of metamorphism continues into the Central Highlands, and into regions so remote from the granite that the author is driven to believe that "without the presence of the Cruachan granite the increasing metamorphism, though possibly more gradual, where that granite now occurs, would have been equally apparent." Evidence of metamorphism when the rocks are traced across their strike is also adduced.

Although the author does not go very fully into the question of the causes of the progressive metamorphism exhibited in tracing these rocks towards and into the Central Highland schists, he had reason to suspect that "the intense regional type of metamorphism was linked with the same phenomena that afterwards resulted in the irruption of the granite-masses."

III.—June 7, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Mr. F. A. Bather, in exhibiting, on behalf of Mr. R. D. Darbishire, a pebble found in gravel near St. Margaret's, Bowdon (Cheshire), said that it consisted of liver-coloured quartzite, and no doubt once formed part of the Bunter Pebble-beds, though these do not occur in the immediate neighbourhood of Bowdon. It had been reported to Mr. Darbishire as found in river-gravel; but reference to Sheet 80 N.E. of the Geological Survey map (1 in. Drift) showed that the deposit was Drift of alleged glacial origin. The specimen was an exceedingly perfect and characteristic example of the pyramid-pebbles or 'Dreikanter,' such as are found in the 'Diluvium' of the North German plain, and in other parts of the world from the Cambrian to rocks now forming, but hitherto not recorded from England. These have been explained as due to: (1) human agency, (2) glacial action (Theile), (3) compression in a pebble-bed ('Packungstheorie' of Berendt), and (4) action of wind and sand. The last explanation was the only one that met the facts of the case, as proved by A. von Mickwitz (Mém. Soc. Imp. Minéral. St. Pétersb., ser. ii, vol. xxii, pp. 82–98, pls. viii, ix, 1887).

In illustration of his remarks, Mr. Bather exhibited a series of specimens which had been collected under the guidance of M. Mickwitz from the locality described by that author on the shore of the Obersee, south of Reval, Esthonia. They confirmed the *statement* that the three sides of the pyramids lay at right angles to the directions of the prevailing winds of the district; they showed stages between stones eroded on one face, or on two faces, and the typical 'Dreikanter'; they illustrated the polishing action of the agent on hard, fine-grained material, its differentiating action on coarse-grained; they retained the original water-worn surface and shape on the under side, and a growth of lichen on such small portions of the upper surface as had been sheltered from the wind. Applying this explanation to Mr. Darbishire's specimen, there still remained an unsolved problem: Was the pebble eroded before or during the deposition of the Bunter stratum, or at some time before, during, or subsequent to the transport and deposition of the Drift? The mode of occurrence of the North German specimens shows that they were eroded after the deposition of the beds at the top of which they now lie; and, in the absence of contrary evidence, the same answer must be given provisionally to the preceding questions.

The following communications were read:—

1. "On the Geology of Northern Anglesey." By C. A. Matley, Esq., B.Sc., F.G.S.; with an Appendix on the Microscopic Study of some of the Rocks, by Professor W. W. Watts, M.A., Sec. G.S.

The strata which occupy the northern part of Anglesey have been the subject of much controversy, some geologists considering them (with the exception of a few patches in the extreme north) to be pre-Cambrian, while others maintain that they are of Bala age, and that they are an upward continuation of the black slates that everywhere appear to underlie them to the south.

The author attacks this problem from its palæontological as well as its stratigraphical side. He divides the rocks into three groups, namely: (1) the 'green series,' which forms the floor of the greater part of the area; (2) the 'northern complex,' occupying a tract along the northern coast and including in it (3) some undoubted Ordovician strata. He adduces palæontological evidence that the Ordovician rocks lying in the northern complex are mainly, if not wholly, of Llandeilo age, while the black slates of Central Anglesey appear to range into Llandovery. The field-evidence shows *inter alia* that the asserted interstratifications of the Green Series and the southern Ordovician are the deceptive results of thrust-planes which have driven the barren green rocks over the Ordovician beds, the latter being in other places made up of fragments derived both from the Green Series and from the rocks of the northern complex.

The contortion, overfolding, cleavage, dislocation, and disruption which the rocks have undergone are next described. Disruption is traced from its early stages into 'crush conglomerates.' Some of the disrupted rocks are Ordovician, and traces of ancient dykes have been found rent to pieces by the movement, which is stated to be post-Ordovician and pre-Carboniferous. The detached masses of limestone and the isolated 'quartz-knobs' of the northern complex are considered to be portions of strata which have suffered disruption in the same way as the thinner hard bands in the crush-zones.

The author contents himself with a general account of the Ordovician rocks near Cemmaes and Porth Wen. He includes among them a purple conglomerate and the *Orthis Bailyana* beds. Though much inclined to the opinion that the green strata and the northern complex are pre-Cambrian, he admits the possibility of their being of any age up to and including the Arenig.

The Appendix contains notes on some of the rocks from the Green Series and the Ordovician System, the quartzites, and the crush-conglomerates.

2. "On an Intrusion of Granite into Diabase at Sorel Point (Northern Jersey)." By John Parkinson, Esq., F.G.S.

In the early pages the general character of this intrusion is described. From a consideration of the field-evidence the author concludes that only the earlier injections of the intruding granite did the work of melting and absorption; that a latter injection, probably with no pause, succeeded, taking the same direction as that followed by the first, and carried forward with it this earlier granite, now rendered basic through the more or less complete absorption of diabase fragments. There has been no diffusion of the basic material thus acquired through this second granite. It is pointed out that this explains the intermingling and interstreaking of the two varieties of granite seen on the coast; the one porphyritic and crowded with fragments, the other non-porphyritic and devoid of fragments.

Following this general introduction, the characters of the granite are described in some detail; then those of the diabase, formerly an ophitic dolerite. Details of structure of the granite in which absorbed basic material is present, and of the diabase into which acid material has permeated, are dealt with: particular attention being directed to the great alteration which the diabase has undergone; this has frequently amounted to a total reconstitution. In this connection are noticed the prevalence of biotite as a product of such mixing and reconstitution when acid material is present in quantity, and the almost entire absence of augite under similar circumstances. In rocks of heterogeneous origin into which the diabase has largely entered, similar features are described: the presence of nests and veins of acid minerals, the entire loss of ophitic structure, the frequent occurrence of much quartz, and the presence of a mineral believed to be sillimanite. The corrosion and reconstitution of the acid felspars under some circumstances are figured and described; the early stages of such alterations are touched upon, and a table is given showing the gradual increase in specific gravity with increase of absorbed material.

In conclusion, points of resemblance and of difference are noted between this district and others; and an interesting slide from Alderney is described, showing the probable extension of such rocks in other directions.

CORRESPONDENCE.

THE RIVER OF THE BALTIC.

SIR,—In reference to Professor Bonney's letter in the GEOLOGICAL MAGAZINE for this month, will you allow me to say that some light on the origin of the remarkable channel which follows the southern coast of Norway seems to be thrown by reference to Dr. Kjerulf's map of the ice-striæ and course of the erratic blocks in his work, "Geologie des Süd. und Mit. Norwegen," Taf. vi, p. 25, from which it will be seen that the erratic blocks have been carried for long distances westwards along the path indicated by the deep channel between the Christiania Fiord and Stavanger. On the other hand the land striæ point southwards; so that the direction of the ice-drift on the submerged portion is perpendicular to the general course of the movement of the ice on the land to the north. The question arises, were the movements of the ice on the land southwards, and that of the ice westwards, on the coast, contemporaneous; or do they represent different epochs of the Pleistocene period? If contemporaneous, the land-ice must have been diverted from its normal course by some opposing barrier; if referable to different epochs, the erratic blocks may have been carried by floating ice along with the trend of the current passing outwards through the Skager Rak; or they may have been carried by land-ice during an epoch of elevation, while the ice itself, in the form of a great glacier, may have ploughed out the loose material with which the whole floor of the Skager Rak may once have been covered, and piled it up on either hand as it moved along. The origin of this channel is certainly a difficult problem; but I feel satisfied it can only be solved by considerations connected with the movements of the land-ice over the unsubmerged portions and those of the submerged. EDWARD HULL.

June, 1899.

THE GEOLOGY OF THE COUNTRY AROUND CARLISLE.

SIR,—In your review of Mr. Holmes' Memoir of the Geology of the Country around Carlisle, you state that "the conclusions at which Mr. Holmes arrived were not those to which Mr. Aveline and the late Sir Andrew Ramsay could agree." As I have never seen Mr. Holmes' Memoir, or knew that it was published, I do not know what these conclusions are. But I have always maintained that no part of the St. Bees Sandstone represented any part of the Bunter Sandstones of the Midland or Northern Counties, but was more probably represented by what has been mapped in Yorkshire as the "Middle Marls and Sandstone" and the "Upper Magnesian Limestone" (a very misleading name). I have never stated that there could be no passage from the Permian up into the Trias, but just the reverse; I have also stated that there was a much greater conformity between the so-called Middle Marls and Upper Limestone (which are classed with the Permian in Yorkshire) with the Bunter Sandstone than with the Lower Magnesian Limestone below them. My anxiety is not so much for the retention of names, but that every formation should be placed on its proper horizon, and I cannot believe that the proper horizon of the St. Bees Sandstone is the same as the Bunter Sandstones. W. T. AVELINE.

15, KENNINGTON TERRACE, KENNINGTON PARK, S.E.

THE PERSIAN VOLCANO KOH-I-TAFTAN.

SIR,—In a footnote to a joint paper by my son and myself on the rocks of the Baluch-Afghan frontier (Q.J.G.S., vol. liii, p. 289), we gave a short account of a visit by Captain P. Molesworth Sykes to the volcano of Koh-i-Taftan, 12,600 feet high, situated near the eastern border of Persia, about 200 miles north of the Arabian Sea.

Captain P. Molesworth Sykes, who is now Consul at Sistan (Seistan), paid a second visit to Taftan (*Koh* means 'mountain' and -*i*- 'of') last January, and he writes to me as follows:—"When passing the eastern base of Taftan, Wood of the Telegraphs and myself tried to scale it from that side. At about 12,000 feet elevation we found seven orifices from which white vapour was being ejected with a noise like that of a steam-engine. The holes were very small and covered with stones, while, all around, were sulphur and sal-ammoniac. I collected here three tins full of the sulphur, the ash, and the stone. Almost at the summit the road was barred by perpendicular cliffs some 30 feet high, and so we could not reach it. The vapour issuing from the seven orifices (two being much bigger than the others) was visible for a distance of 10 or 15 miles, while the ground close to me was hot enough to break the bulb of my register. The climb was much steeper than on the south-west side, or perhaps I had not quite got over my seediness of the previous summer."

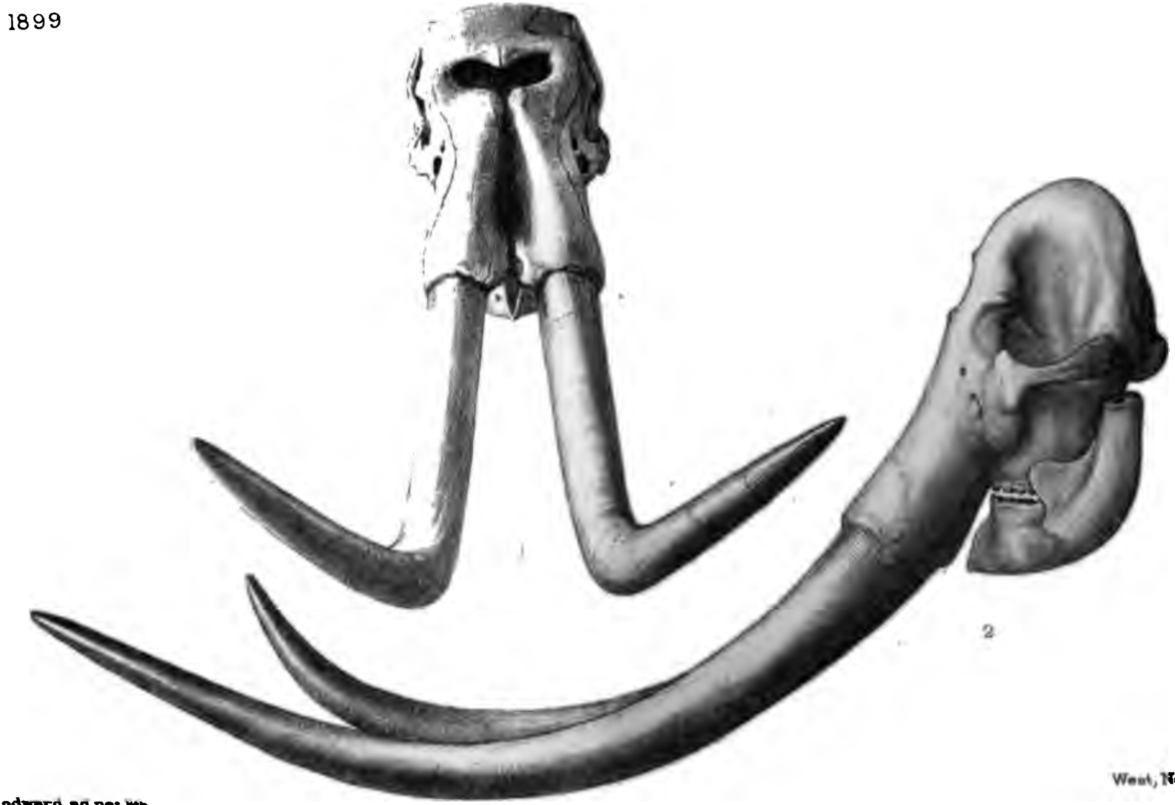
As so little is yet known about the Taftan volcano, and as it lies so much outside the range of ordinary travellers, the above brief account of Captain Sykes's second visit to this locality is interesting. The great heat of the ground near the orifices through which steam is still ejected under considerable pressure shows that the fires of this old volcano have not yet completely died out.

Captain Sykes kindly sent me the specimens he collected, but as they have not yet arrived I am afraid they have gone astray *en route*, or have been confiscated by some over-zealous Persian official who, in his care for the morals of Europe, may have thought that suspicious intercourse with the infernal regions ought not to be encouraged.

Should Captain Sykes again visit Koh-i-Taftan, it would be interesting if he could make a good representative collection of the solid rocks of that mountain found *in sitû*.

I would remind those who may think it strange that an active volcano should have existed so far away from the sea that in Eocene times the sea flowed over what is now the Indus Valley into Baluchistan and Afghanistan (Manual Geol. India, 2nd ed., p. 494). This sea did not *commence* its retreat until the end of the Eocene period; and whilst it remained, the Koh-i-Safid range, of which Koh-i-Taftan forms a part, was probably not far removed from *its shore*. C. A. MCMAHON, Lieut.-General.

20, NEVERN SQUARE, S.W.



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West, Newman imp.

Elephas ganesa, *Falconer & Cautley*, Pliocene, Sewalik Hills India.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. VIII.—AUGUST, 1899.

ORIGINAL ARTICLES.

I.—NOTES ON *ELEPHAS (STEGODON) GANESA*, FALC. & CAUT., FROM THE PLIOCENE DEPOSITS OF THE SEWALIK HILLS, INDIA.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S., etc.

(PLATE XIV.)

INDIA, the present home of one of the two types of existing elephants (*Elephas Indicus*), has also yielded abundant evidence of numerous extinct forms of this animal; two species of *Dinotherium*, eight species of *Mastodon*, and seven species of extinct elephants being recorded from the Miocene and Pliocene formations of that great continent.

Elephas ganesa, the subject of these notes, was probably one of the largest of all the fossil elephants known, and is represented in the Geological Gallery of the British Museum (Natural History), Cromwell Road, by a skull from the Sewalik Hills, India, the tusks of which measure 10 feet 6 inches in length outside the alveolar portion, and 2 feet 3 inches more within the alveolus.

This superb specimen, presented to the Trustees in 1848 by General Sir William Erskine Baker, K.C.B., has quite recently been remounted in an improved position in the centre of the Gallery, and a lower jaw has been added to the cranium, which greatly increases the interest of the specimen. The tusks, which, by compression in the rock, had been squeezed close together, and presented an abnormal appearance, have now been set up wider apart, so as to allow of a sufficient interval for the insertion of the proboscis, as would of necessity have been the case in the living animal.

Turning to Falconer's Palæontological Memoirs[1] (vol. i, p. 20), we find he proposes the following classification of the species of *Mastodon* and *Elephas*, based upon the ridge-formula and structure of the molar teeth. After dividing the Mastodons into Trilophodonts and Tetralophodonts, Falconer proceeds to classify the elephants into three sectional groups, namely: I, *Stegodon*; II, *Loxodon*; III, *Elasmodon*. In the first of these divisions (*Stegodon*), Falconer placed those species which Owen called 'Transitional Mastodons.'

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[1] "Palæontological Memoirs and Notes of the late Hugh Falconer, M.D., V.P.R.S., For. Sec. Geol. Soc." (1868), compiled and edited by Chas. Murchison, M.D., F.R.S. Two vols., 8vo (plates).

This group, he tells us, forms the nearest approach to the Mastodons; indeed, Clift gave them the designation of *Mastodon elephantoides*. A fragment of one of the teeth, denuded of its coat of cement, and seen by a naturalist for the first time, would at once be referred to *Mastodon* rather than to *Elephas*. But when the essential characters are analyzed, the species are seen to partake more of the nature of true elephants.

Writing on the characters of the *Stegodons*, Falconer observes: "Sir Proby Cautley and myself have thought we could distinguish four species of *Stegodon*—namely, *S. Cliftii*, *S. bombifrons*, *S. insignis*, and *S. ganesa*."

In his Catalogue of the Fossil Mammals in the British Museum (Natural History), 1886, part iv, p. 88, R. Lydekker writes:—"The third true molars in the type cranium of this species contain ten ridges, and thereby agree with the corresponding teeth of *E. insignis* rather than of *E. bombifrons*, a conclusion confirmed by a second cranium, in which there appear to be either ten or eleven ridges in the same tooth. This close resemblance between the last molar of this form and of *E. insignis* renders it apparently impossible to draw any distinction between the earlier teeth of the two forms, and all such teeth are therefore referred to the latter. Falconer had considerable doubts as to the specific distinctness of the present form, and as the resemblance between the type cranium and the young cranium of *E. insignis* indicates that the two are closely related, it is possible that *E. ganesa* may be the male form of *E. insignis*." "The adult cranium," he adds, "does not differ very widely from the type of *E. indicus*, although the frontal constriction is less marked." This last observation was probably due to the former unnatural position in which the skull of *E. ganesa* was mounted. Anyone viewing the skull, as now placed in its normal position, i.e. with the grinding surface of the molars upon a nearly horizontal line (Pl. XIV, Fig. 2), and comparing it with the above woodcut (which shows the position of the head as originally set up, and as figured in the "Fauna Antiqua Sivalensis"), *cannot fail to be struck by the great change produced in the aspect of the fossil.* The cranium in profile, measured from the palate to

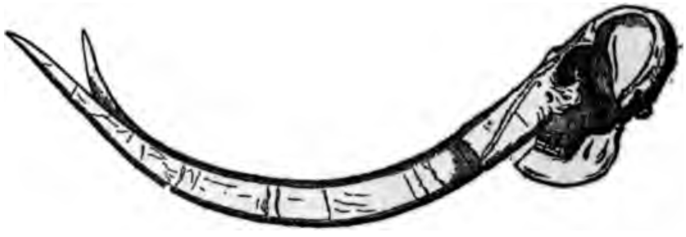

Figure showing the original position of the skull of *Elephas ganesa* (reduced to $\frac{1}{32}$ nat. size), as formerly mounted in the Geological Gallery of the British Museum (Natural History), after Prof. A. Gaudry's "Les Enchainements du Monde Animal," 8vo, 1878. The present position of the skull is shown in Pl. XIV, Fig. 2.

vertex, is seen to be nearly twice as high as it is deep when asured from the nares to the occiput. This brachycephalic aracter of the skull, producing so elevated and narrow a profile the head, is greatly accentuated by the addition of the lower jaw the specimen.

Continuing his observations on the several specimens referred him to *Elephas ganesa*, Falconer (on p. 80, op. cit.) describes ertical section of the last upper molar attributed to an undescribed dian fossil elephant, named *E. ganesa* in this work.[1] "The own consists of ten principal ridges, with a subordinate 'talon' lge in front and behind. The anterior seven ridges have their mmits worn, the two in front being ground down to the common se of ivory, the tooth having been a considerable time in use.

"The disposition and relative proportions of the ivory, enamel, and ment bear the closest resemblance to those of the corresponding oth of *E. insignis*" (op. cit., pl. iv, fig. 1), "and the number of lges agrees" (see also op. cit., vol. i, p. 424). Dr. Falconer adds: Notwithstanding that the molars agree so closely, the crania e remarkably different in the two forms; that of *E. insignis* is gularly modified, being much compressed on the vertex, so as bear an analogy to the cranium of *Dinotherium giganteum*; while e head of *E. ganesa* does not differ much from the ordinary type elephant."

The following description of the large skull of *Elephas ganesa* om the Sewalik Hills, presented by Colonel Baker to the British useum, is taken from Falconer's "Pal. Memoirs," vol. i, p. 453, ing the explanation of pl. xxi of Falconer & Cautley's "Fauna ntiq. Sival." (issued without text): "Large skull with left incisive *sitú*, and fragment of right incisive detached. The incisive veoli are remarkably elongated, as in *E. primigenius*. The plane the incisives is continuous with that of the frontal, but with tendency to obliquity forwards. The skull is very imperfect on e right side. Pl. xxi gives a front view one-fifth of the natural ze, and pl. xxii, figs. 1 and 2, gives a lateral and palatal view of e same skull."

The dimensions are as follows (op. cit., p. 454):—Length of anium from occipital protuberance to the end of the incisive left le (4 feet exactly), 48 in. From occipital condyles to left side, in. From occipital condyles to anterior border of molar alveolus, ·5 in. Vertical height from condyles to sinciput, 24·5 in. Diameter ross the occipital condyles, 9·2 in. Antero-posterior diameter of ft condyle, 5·1 in. Transverse diameter of right condyle, 3·85 in. ansverse diameter of occipital foramen, 3 in. Antero-posterior ameter of occipital foramen, 3·1 in. From the surface occipital lge plane to the anterior entire margin of naso-maxillary sinus, ·1 in. Semi-diameter of widest part of occipital (making total occiput 29·2 in.), 14·6 in. Semi-diameter (transverse) of naso-axillary sinus (entire diameter restored estimated 16 in.), 7·9 in.

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[1] "Pal. Mem.," vol. i, p. 80, pl. vi, fig. 1; or "Fauna Antiq. Sival.," pl. iii, . *7a*. Length of tooth, 9·25 inches.

Interval between naso-maxillary sinus and post-orbital margin of frontal, 4·55 in. Mesial width across forehead from post-orbital process to inner margin of incisive left side, 13·1 in. (width of forehead at this part restored, 26·25 in.). From tip of post-orbitary process to surface of occipital, 17·75 in. From tip of incisives outside to post-orbitary process, 30·75 in. Length of incisive to margin of naso-maxillary sinus, 31 in. Depth of zygomatic fossa, 4·25 in. Estimated width of cranium between middle of zygomatic fossæ, 19·5 in. Height from lower margin of auditory foramen to the summit of sinciput, 18 in. Depth or height of cranium from the posterior margin of molar alveolus (back part of palate) to the summit of sinciput, 32 in. Depth from posterior and upper margin of occipital foramen to posterior margin of molar alveolus, 9·5 in. Height of the orbit, 8·78 in. Length of anterior portion of the palate, and from anterior end of molar alveolus to tip of incisive, 16 in. Transverse diameter, left incisive at tip, 11·5 in. (Estimated width of both incisives at tip, 24 in.) Vertical diameter of left incisive at tip, 10·6 in. Vertical height of sub-orbitary foramen, left, 3·85 in. Width of incisive at contraction below sub-orbitary foramen, 10·75 in. Width of incisive sheath at sub-orbitary foramen, 7·5 in. (Estimated width of both incisive sheaths at sub-orbitary foramen, 21·5 in.) Interval between posterior molars, anterior end (width of palate in front), 2·7 in. Interval behind, 3·25 in. Length of right molar (backmost), 11·9 in. Width of right molar in front, 4·05 in. Width of right molar behind, 5 in. Vertical height from posterior outer margin of molar alveolus to post-orbitary process, 21 in. Interval between outer surfaces of the molars at fifth ridge from front, 12·6 in. Antero-posterior diameter, auditory foramen, 1·15 in. Transverse diameter, auditory foramen, 1 in. Estimated height of occiput at restoration from lower surface of condyles to sinciput, 24·5 in. Length of left tusk outside the incisive sheath, measured along the lower surface, 10 ft. 6 in. Length of left tusk inside the sheath, 2 ft. 3 in. to 2 ft. 4 in. Estimated total length, 12 ft. 9 in. Total length of head from occipital protuberance to tip of tusk, 4 ft. + 10 ft. 6 in. = 14½ feet. Length of right tusk, 10 ft. 8½ in. Interval between the tusks at emergence from incisive sheath, 6 in. Interval between the tusks at nearest approximation, at 3½ feet from incisive, 3·5 in. Divergence at tips, 5 ft. 3½ in. as restored. Height of versed sine of curve from tip to incisive border, right side, 23 in. Height of versed sine of curve from tip to incisive border, left side, 23 in. Vertical diameter left tusk (14 in. from base) where greatest, 9 in. Transverse diameter, left tusk, at ditto, 7·9 in. Girth of left tusk at ditto, 26 in.

Referring to the molar teeth of *E. ganesa*, Falconer writes (of pl. iii. fig. 7*b*, "Fauna Antiqua Sivalensis") on p. 81, "Pal. Memoirs":—This figure "shows a vertical section of one of the posterior molars of the lower jaw, which we infer to belong to the same species. A small portion of the anterior end of the crown has been broken off; but the presence of the anterior fang proves that the section includes the whole length of the tooth except the first ridge,

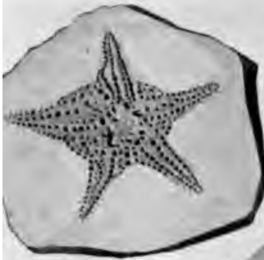

Fig. 2*a*.

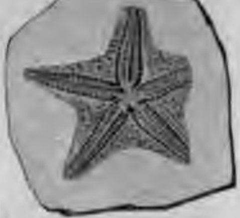

Fig. 2*b*.

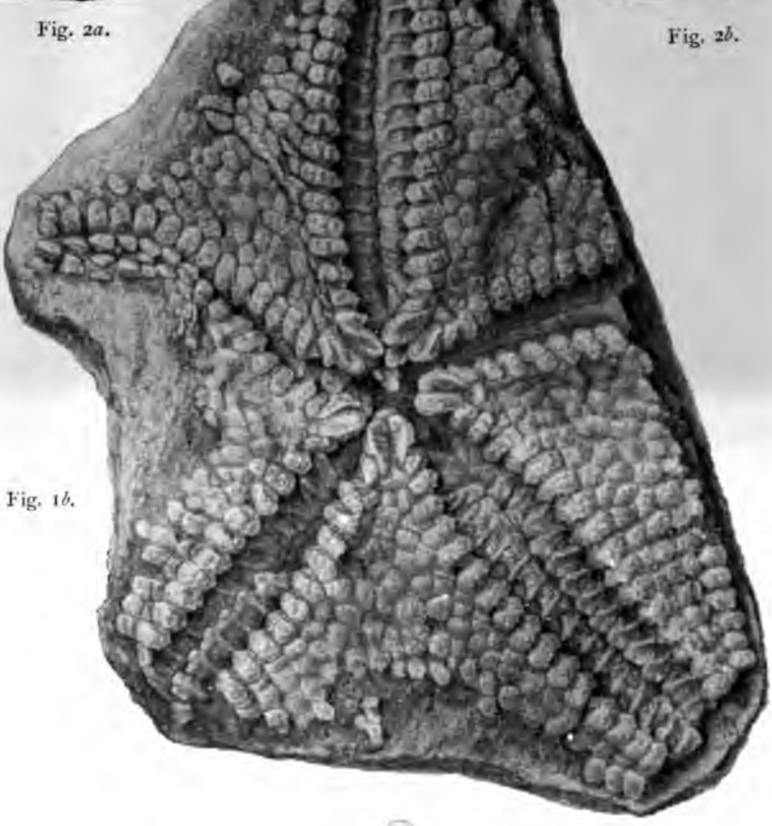

Fig. 1*b*.

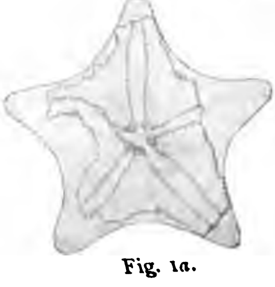

Fig. 1*a*.

Figs. 1a, b, Lindstromaster antiqua, and Figs. 2*a*, *b*, *Palæasterina Bonney*

Fig. 1. from a drawing of the type-specimen by Geo. Liljevall.

the posterior end being entire. It appears to have consisted of eight principal ridges, with a 'talon' ridge behind and a subordinate ridge in front. Five of the ridges have been in use, the anterior two in the section being worn down close to the common base of ivory, while the three last ridges are entire. Like the upper molar of *E. ganesa* (already referred to), it bears a close resemblance to the corresponding inferior tooth of *E. insignis* (pl. iv, fig. 1, op. cit.) in the form of the ridges, thickness of enamel, and proportion of cement. This specimen measures about 7½ inches in length (see also op. cit., vol. i, p. 424)." In the same work,[1] he describes (pl. xx A, figs. 1 and 1*a*) a "Lower jaw with first and second true molars, of *Elephas ganesa* (Falc. & Caut.), from the Sewalik Hills. Proved to be so by fig. 2. A most remarkable jaw, very high in front and with very divergent rami behind; diastemal edges very sharp; two outer mentary foramina on right side. The front tooth much worn; has five ridges and a heel; the last tooth has eight ridges." Falconer adds, "Nothing else like this in the collection, B.M."

Extreme length of jaw, 18·5 in. Height at alveolus, 8·5 in. Width of jaw in front, 4 in. Width of jaw behind, 5·8 in.! Length of front tooth, 5·1 in. Width, 2·7 in. Length of last tooth, 9·3 in. Width, 3·2 in.

Figs. 2 and 2*a*.—*Elephas ganesa.* Portion of lower jaw with left penultimate lower molar. The jaw in this specimen is also very high and narrow in front and low behind. The tooth has seven ridges and a heel. Behind it is seen a portion of the last molar. B.M. Length of fragment, 14·5 in. Height at alveolus, 8·3 in. Height behind, 5·8 in. Width in front, 3·3 in. Width behind, 6·6 in. Length of molar, 9·2 in. Width at back, 3 in.

EXPLANATION OF PLATE XIV.

Figs. 1 and 2.—*Elephas ganesa*, Falc. & Caut. Fig. 1, front view, and Fig. 2, profile, of skull and tusks, as now exhibited in the Geological Gallery of the British Museum (Natural History), Cromwell Road. The specimen measures 14⅓ feet in length. From the Pliocene of the Sewalik Hills, India. Presented by General Sir William Erskine Baker, K.C.B., 1848.

II. — On *Lindstromaster* and the Classification of the Palæasterids.

By J. W. Gregory, D.Sc., F.G.S.

(PLATE XVI.)

THE classification of the Palæozoic starfishes has long been in chaos. The earlier palæontologists, who founded most of the known genera, made no attempt at a general classification or to indicate the relations between the Palæozoic and existing representatives of the Asteroidea. The first step towards progress was Bronn's[2] division of the extinct genera into three groups—the Ophiurasteriæ (which may be left out of account as Ophiuroidea), the Encrinasteriæ, and the Asteriæ veræ. The last two groups have been accepted by most palæontologists who have referred to the group. Thus they were adopted by von Zittel,[1] who simply redefined the genera, and by Stürtz,[2] whose important papers included the first attempt at a formal classification.

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[1] Falconer & Cautley's "Fauna Antiqua Sivalensis" (the figures of which are described in Falconer's "Pal. Memoirs," 1868, vol. i, p. 452).

[2] H. G. Bronn: Classen und Ord. Thierreichs, vol. ii (1860), pp. 287–8.

The character on which Bronn's groups were based is the arrangement of the ambulacral ossicles. In the Encrinasteriæ (or Palæasteroidea as they are sometimes called) the ambulacral ossicles are said to be alternate, whereas in the Asteriæ veræ or Euasteroidea they are said to be opposite in position. The alternation of the ambulacral ossicles is no doubt the primitive arrangement; and it is a character of great importance among ophiurids, for so long as it was retained the union of the pairs of ambulacral ossicles into vertebral ossicles was impossible. But among the asterids the character is not essential; for the ambulacral ossicles in each pair never fuse, but remain as independent bars, meeting at their narrow ends. The alternation may at any time result from growth pressure. In some starfish the ambulacral ossicles in one part of a ray may be alternate, while in another part they may be opposite. The character is, moreover, difficult to use, as in some asterids the two series of ambulacral ossicles appear to have a certain amount of movement past one another during the lateral bending of the arm.

The alternation or opposition of the ambulacral ossicles is therefore not a good character for the primary subdivision of the Asteroidea. That the older asterids had alternate ambulacrals is only to be expected, for that was naturally the primitive arrangement. It was gradually lost as the ambulacrals became reduced in size and the arms more flexible. The artificial nature of the divisions based on this character is shown by the action of Stürtz, who divided several of his families into two parts, and placed one part in the Encrinasteriæ and the other part in the Asteriæ (or Stelleridæ) veræ. Thus his family Palæechinasteridæ comprised the genera *Echinasterella* and *Palasteriscus*. The former he placed in the Encrinasteriæ and the latter in the Asteriæ veræ.

Nor is it possible to use the alternation or opposition of the ambulacral ossicles as a basis for the divisions Palæasteroidea and Euasteroidea, for Bronn, von Zittel,[3] and Nicholson[4] have correctly included some of the Palæozoic asterids in the Asteriæ veræ.

Bronn's classification appears, therefore, neither morphologically nor historically justifiable, and a more convenient system is desirable. In 1889 Sladen[5] founded the two groups, the Phanerozonia for asterids having large marginal plates and the dermal branchiæ confined to the abactinal surface, and the Cryptozonia for asterids having the marginal plates rudimentary or absent and the dermal branchiæ not confined to the abactinal surface. Sladen founded these divisions only as orders of Euasteroidea. But Stürtz in 1893 subdivided the other section, or Encrinasteriæ—with which the group of Palæasteroidea must be entirely or mainly identical—also into Phanerozonia and Cryptozonia; and then in turn he subdivided the Stelleridæ veræ in the same way. It seems to me possible to extend still further Stürtz's extension of Sladen's classification, and to divide the Asteroidea primarily into Phanerozonia and Cryptozonia, abandoning Bronn's classification altogether.

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[1] K. von Zittel: Handb. Palaeont., vol. i (1879), pp. 451–4.

[2] B. Stürtz, "Neuer Beitr. Kennt. palaeoz. Seesterne": Palæontogr., vol. xxxvi (1890), pp. 246–7. "Über verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. v (1893), pp. 76–7.

[3] K. von Zittel: Handb. Palaeont, vol. i (1879), p. 454.

[4] H. A. Nicholson: Man. Pal., vol. i (1889), p. 397.

[5] W. P. Sladen, "Report on Asteroidea collected by 'Challenger'": Rep. *Chall. Exp.*, Zool., vol. xxx, pp. xxviii and xxxiv.

It is true that M. Perrier[1] has criticized the fundamental principle of Mr. Sladen's system, which is not free from difficulties; but his alternative plan[2] is certainly less helpful in the study of fossil starfish.

About three years ago I rashly undertook to prepare a synopsis of the known Asteroidea, which had to be completed by September, 1896. I accordingly endeavoured to bring the fossil and recent genera into line by the above suggested extension of Sladen's system. The classification is necessarily provisional, and was prepared in reliance on Bacon's maxim that truth more often springs from error than from ignorance. I hoped that a clear series of definite family diagnoses would show the gaps in our knowledge of the anatomy of Palæozoic starfish, and thus help toward something better. This classification having been prepared, I delayed the publication of this paper until the diagnoses were available for reference.

Some years back, owing to the kindness of the late Dr. Johnstrup of Copenhagen, I received, through the agency of Professor Lindström and my colleague Mr. F. A. Bather, the loan of the type-specimen of Hisinger's *Asterias antiqua,* which is now preserved in the Mineralogical Museum of Copenhagen. As the original figure was diagrammatic and indefinite, the specimen had been redrawn by Mr. Georg Liljevall of Stockholm, with the scientific accuracy and artistic skill for which his work is famous. This drawing, which is the property of the Riksmuseum in Stockholm, has been kindly lent me by Professor Lindström, who has also permitted the accompanying plate to be prepared from it. For Professor Lindström's indulgence in allowing me to retain the drawing—I am ashamed to say for how long—I owe him my sincerest thanks.

The history of this species is simple. It was founded by Hisinger[3] in 1837, and assigned to the genus *Asterias.* In 1848 it was transferred to *Palmipes* by Edward Forbes, owing to a mistake as to its geological age, which he regarded as Cretaceous. Salter in 1857 removed the species to the genus *Palæasterina,* which he apparently considered an ally of *Palmipes*; for he remarked regarding the type species of the genus, that Forbes "would have referred it, and with it the whole group, *to their true position near Asteriscus* (*Palmipes*)." Since that date the species has always been included in *Palæasterina*, as by Lindström, who in 1888 published a synonymy of the species.

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[1] Ed. Perrier, "Contrib. ét. Stell. Atl. Nord": Result. Camp. Sci. Albert I., fasc. xi (1896), pp. 10–14.

[2] Ibid., pp. 7, 15.

[3] The references are given in the synonymy on p. 347.

It is, however, quite clear that the species belongs to a genus distinct from *Palæasterina*. I therefore propose to call it *Lindstromaster*, as it comes from the beds which will always be associated with Professor Lindström's name. The word is open to criticism as being a mongrel composed of Swedish and Greek. But so long as such terms as glaciology are in current scientific use, and so long as we give animals such names as *Nautilus imperialis*—a mixture of good Greek and bad Latin—other convenient mongrel terms may be tolerated. And *Lindstromaster* is certainly convenient. It not only shows at once that the animal is a starfish, but by reference to the name of the distinguished authority on the Swedish Silurian fauna suggests the age and country in which the genus lived. The name has many precedents, as, for instance, *Salteraster*, which is as hybrid etymologically and as instructive palæontologically.

To illustrate the affinities of *Lindstromaster* and simplify its description it will be advisable to include diagnoses of the Palæasteridæ and Palæasterinidæ. The present opportunity is also taken for the description of two new species and the institution of three other new genera.

Class STELLEROIDEA.

Subclass ASTEROIDEA.

Order 1. PHANEROZONIA.

Family 1. PALÆASTERIDÆ.

DIAGNOSIS.

Phanerozonia with the ambulacral ossicles all or mostly alternate in position. The madreporite is abactinal, and the oral armature adambulacral. The skeleton of the abactinal surface and interradial areas is tessellate. Marginal plates large.

Subfamily 1. PALÆASTERINÆ.

DIAGNOSIS.

Palæasteridæ with the ambulacral ossicles definitely alternate. The rays are usually long and sharply marked off from the disc, which is always small, with small interradial areas.

1. PALÆASTER, Hall, 1852.

Pal. New York, vol. ii, p. 247 (*non* Salter, Trautschold, De Koninck, etc.).

TYPE SPECIES.—*P. Niagarensis*, Hall, 1852. Op. cit., p. 247, pl. li, figs. 21–23. Silurian—Niagara Series: Lockport, New York.

PALÆASTER CARACTACI, Salter MS.

DIAGNOSIS.

A small species with $R : r$ as $12 : 3\frac{1}{2}$. The arms are therefore *long*. They taper gradually. The infra-marginal plates number

11 or 12 on each side of each ray. They are large, and the exterior side is tumid.

On the abactinal surface of each ray there appear to be three rows of small plates, of which those of the median series are the largest.

The madreporite is large, and placed close by one of the interradial angles.

DIMENSIONS.

	B.M., 48,206.
R	12 mm.
r	3·5 ,,
Width of arm at the base	3·5 ,,

DISTRIBUTION.

Caradoc Sandstone. ? Soudley Quarry, Church Stretton. The specimen on which the above diagnosis is based is contained in a small nodule, and is labelled from the Soudley Quarry. Mr. R. A. Buddacombe has, however, expressed doubt as to the exact correctness of this locality. The specimen is in the British Museum Collection (No. 48,206).

AFFINITIES.

This species was recorded by Salter[1] in 1865, but I am not aware that any description has been published. R. Etheridge, jun., and Nicholson remarked that the species is a true *Palæaster*, an opinion no doubt based on the specimen here described (British Museum, No. 48,206).

The nearest ally of this species is *P. matutina* (Hall),[2] from the Trenton Limestone in the State of New York, which has a single row of large plates filling up the space between the marginals on the abactinal side.

2. ARGASTER, Hall, 1867.

Note on *Palæaster*, 20th Rep. Reg. Univ. New York, p. 287; and Nicholson & Etheridge, jun., Sil. Foss. Girvan, 1880, p. 322.

TYPE SPECIES.—*Asterias antiqua*, Troost, 1835. Trans. Geol. Soc. Pennsyl., vol. i, p. 232, pl. x, fig. 9.

? 3. TETRASTER, Etheridge, jun., & Nicholson, 1880.

Sil. Foss. Girvan, p. 324.

TYPE SPECIES.—*Tetraster Wyville-Thomsoni*, Eth., jun., & Nich., 1880. Op. cit., p. 324, pl. xxi, figs. 1–8.

4. PETRASTER, Billings, 1858.

Dec. Geol. Surv. Canada, No. iii, p. 80.

TYPE SPECIES.—*Palæasterina rigidus*, Billings, 1856. Rep. Geol. Surv. Canada, 1856, p. 291. *Petraster rigidus*, Dec. Geol. Surv. Canada, 1858, vol. iii, p. 80, pl. x, fig. 3. Trenton Limestone: Ottawa.

5. MONASTER, Etheridge, jun., *pars*, 1892.

Mon. Carb. Invert. New South Wales, pt. ii, pp. 70–1.

TYPE SPECIES.—*Palæaster* (*Monaster*) *giganteus*, R. Etheridge, jun., 1892. Op. cit., p. 74, pl. xii.

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[1] *Asterias matutina*, Hall, 1847: Pal. New York, vol. i, p. 91, pl. xxix, fig. 5. *Palæaster matutina*, Hall, 1867: 20th Reg. Rep., p. 283, pl. ix, fig. 2.

[2] Salter: Cat. *Foss. Mus. Pract.* Geol., p. 30.

This is the third species referred by Mr. R. Etheridge, jun., to *Monaster*, but he does not definitely choose any one of the three as the type; the name having been suggested "from the one or single row of adambulacral plates on each side of an ambulacral avenue." *M. giganteus* is the best type; for by adambulacral plates Etheridge no doubt means all the actinal plates except the ambulacrals, as the true adambulacrals are always uniserial. *M. Strutchburii*, Eth., jun., is also a *Monaster*, but *M. Clarkei* is referred to a new genus (p. 353).

Subfamily 2. XENASTERINÆ.

DIAGNOSIS.

Palæasteridæ with the general characters of the Palæasterinæ, but with most of the ambulacral ossicles opposite.

XENASTER, Simonowitsch, 1871.

"Aster. rhein. Grauwacke": Sitz. k. Akad. Wiss. Wien, vol. lxiv, p. 88.

TYPE SPECIES.—*Xenaster margaritatus*. Op. cit., p. 88, pls. i and ii. Devonian: Germany.

AFFINITIES.

This genus has been assigned by von Zittel and Nicholson to the Asteriæ veræ, owing to the opposite position of the ambulacral ossicles, which is the main character of the subfamily to which the genus is here referred. The interradial areas are larger than in typical species of Palæasteridæ, at least in the type of *Xenaster*; but *X. simplex*, Sim., which ought no doubt to be made the type of a new genus, agrees closely with characteristic forms of *Palæaster*, except in the opposite position of the ambulacral ossicles. The value of this character is doubtful since in Simonowitsch's figure of *X. margaritatus* on pl. ii, fig. 3, while some of the adambulacrals are opposite, others are alternate; probably the ambulacral ossicles would vary in the same way. If it should appear on re-examination of the types of the genus that Simonowitsch's figures (e.g., his pl. i, fig. 1*b*; pl. iii, fig. 1*b*) are incorrect, then the subfamily would be unnecessary, and *Xenaster simplex* might enter *Palæaster*, and *X. margaritatus* take rank close to *Palæaster eucharis*, Hall, for which otherwise a new genus is wanted.

Subfamily 3. LINDSTROMASTERINÆ.

DIAGNOSIS.

Palæasteridæ with alternate ambulacral ossicles, a large disc covered with tessellate plates, and large interradial areas.

1. LINDSTROMASTER, nov. gen.

DIAGNOSIS.

Palæasterinidæ with flat pentagonal disc and five short blunt rays.

The plates of the disc are large, polygonal, tuberculate, and crowded into a close tessellate pavement, which completely covers the interradial areas.

Marginal plates well developed and conspicuous, and but slightly smaller than the adambulacrals. Both supra- and infra-marginals appear to be present.

The abactinal furrows are large and subpetaloid. They are bounded by large, tuberculate adambulacral plates. The ambulacral plates are boot-shaped. The pores for the podia are large, and occur on the suture between the adambulacrals and ambulacrals.

The adambulacral elements in the oral armature are prominent, and consist of five pairs of subtriangular plates.

TYPE SPECIES.—*Asterias antiqua*, Hisinger, 1837. Silurian: Gotland.

LINDSTROMASTER ANTIQUA (Hisinger), 1837. Pl. XVI, Fig. 1.

SYNONYMY.

Asterias antiqua, Hisinger, 1837: Leth. Svec., p. 89, pl. xxvi, fig. 6.
,, ,, Hisinger, 1840: Anteckningar, pt. vii, p. 64.
,, ,, Bronn, 1848: Ind. Pal., Nomencl., p. 120.
Palmipes ,, Forbes, 1848, "Aster. foss. Brit.": Mem. Geol. Surv., vol. ii, pt. 2, p. 481.
,, ,, Lindström, 1867: Nom. foss. Sil. Gotl., p. 26.
Palæasterina antiqua, Salter, 1857, "New Pal. Starfishes": Ann. Mag. Nat. Hist., ser. 2, vol. xx (1857), p. 327.
,, ,, Woodward, 1869: *Eucladia*, GEOL. MAG., Dec. I, Vol. VI, p. 244.
,, ,, Lindström, 1885: List foss. Gotland, p. 14.
,, ,, Lindström, 1888: List. foss. Faunas Swed., pt. ii, p. 16.
,, ,, Lindström, 1888: Schichtenf. Sil. Gotl., N. Jahrb., 1888, vol. i, p. 157.
,, ,, Stürtz, 1893, "Verst. und leb. Seesterne": Verh. Nat. Ver. preuss. Rheinl., p. 44.
Asteriscus antiquus, Pictet, 1857: Traité Pal., vol. iv, p. 267, pl. xcviii, fig. 4.

DIAGNOSIS.

Disc small, with the ratio of $R : r$ as 18 : 11.

The interradial areas (and the whole 'squelette ventro-lateral' of Perrier) are wide, and include 9 or 10 plates in width across the radius to the interradial angle.

The adambulacral plates number about 20 in each series.

DIMENSIONS.

	Hisinger's figure.	Measurements from the specimen.
R	18 mm.	18 mm.
r	13 ,,	11 ,,
Maximum width of ambulacral furrow	3 ,,	3 ,,

DISTRIBUTION.

Bed *C*, corresponding to the Wenlock Shale, Gotland.

FIGURES.

Pl. XVI, Fig. 1. Actinal surface of the type-specimen, Angelin Coll., Mineralogical Museum, Copenhagen. Fig. 1*a*, the outline of the specimen, nat. size; Fig. 1*b*, the same, × 4 dia.

2. URANASTER, nov. gen.

[From Uranus, the grandfather of Pluto; the starfish resembles the living genus *Plutonaster*.]

DIAGNOSIS.

Lindstromasterinæ with a large disc and five long, gradually tapering arms.

The marginal plates are large. On the abactinal surface they are separated by numerous closely fitting plates, with convex upper surfaces, so that they appear tubercular. These intermediate abactinal plates are arranged in alternate, transverse rows. No carinal abactinal plates.

Ambulacral plates traversed by strong transverse ridge. Adambulacral plates thick and tubercular.

TYPE SPECIES.—*Palæasterina Kinahani*, Baily, 1879. Mem. Geol. Surv. Ireland, Sheet Nos. 169, 170, 180, 181, p. 58, fig. 6; p. 59.

AFFINITIES.

The genus differs from *Lindstromaster* by its long rays and transverse rows of abactinal intermediate plates.

URANASTER KINAHANI (Baily), 1879.

DIAGNOSIS.

Medium-sized starfish, with *R* of about 30 mm. and *r* of about 7 mm. The arms are 8 mm. across at the base.

Marginal plates elongated in the direction of the arm; about 30 supramarginals on each side of each ray.

Abactinal intramarginal plates consist of an outer row of large submarginal plates, alternating with the marginals; small plates sometimes occur in the angle between these plates and the marginals. Within the submarginal plates there is on each side of the ray a row of three or four small tubercular plates. There is no carinal series.

The plates in the actinal interradial areas are irregular and polygonal.

The actinal furrow was apparently narrow, tapering gradually, and deep.

DISTRIBUTION.

Caradoc: Wexford. The above diagnosis is based on specimen E 194 in the British Museum; it was collected near Bannon.

Family 2. PALÆASTERINIDÆ.

DIAGNOSIS.

Phanerozonia with the ambulacral ossicles alternate, the oral armature adambulacral, and the madreporite abactinal. The disc is large and pentagonal, and the rays are short and separated by large interradial areas. The marginal plates are smaller than the adambulacral plates.

AFFINITIES.

The family agrees with the Palæasteridæ in the three first characters stated; but differs from it by the shortness of the rays and large size of the disc, and by the less development of the marginal plates. The family differs from the Aspidosomatidæ by the fact that the rays are never petaloid, and by the absence of the abactinal depressions between the marginal plates and the longitudinal series of abactinal arm plates.

1. PALÆASTERINA, McCoy, 1851.

SYNONYMY.[1]

Palæasterina, McCoy, 1851: Brit. Palaeoz. Foss., fasc. i, p. 59.
,, *pars*, Salter, 1857, "New Pal. Starfishes": Ann. Mag. Nat. Hist., ser. 2, vol. xx, pp. 324, 327.
,, *pars*, Billings, 1858: Dec. Geol. Surv. Canada, No. iii, p. 76.
,, *pars*, Salter, 1859: in Murchison, "Siluria," 3rd ed., p. 248.
non ,, Dana, 1863, "Note foss. Echinod.": Amer. Journ. Sci., ser. 2, vol. xxxv, p. 295.
non ,, Hicks, 1873, "Tremadoc St. Dav.": Quart. Journ. Geol. Soc., vol. xxix, p. 51, pl. iv, figs. 21–23.
non ,, Baily, 1879: Mem. Geol. Surv. Ireland, No. 169, etc., p. 58.
,, von Zittel, 1879: Handb. Palaeont., vol. i, p. 453.
non ,, Etheridge, 1881: Pres. Add., Quart. Journ. Geol. Soc., vol. xxxvii, Proc., p. 92.
,, *pars*, De la Touche, 1884: Handb. Geol. Shrops., p. 34.
non ,, Stürtz, 1886, "Beitr. pal. Seest.": Palæontogr., vol. xxxii, p. 96.
,, Stürtz, 1890, "Neu. Beitr. pal. Seest.": ibid., vol. xxxvi, p. 226.
,, *pars*, Stürtz, 1893, "Ueber verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 43.
Uraster, *pars*, Forbes, 1848, "Aster. foss. Brit.": Mem. Geol. Surv., p. 463.
,, ,, Forbes, 1849: Dec. Geol. Surv., No. i, pl. i.

DIAGNOSIS.

Palæasterinidæ with the rays shortly produced but distinctly marked off from the disc. *R* is about twice as great as *r*.

The skeletal plates are large and thick, but not packed into a tessellate pavement, the separate plates on the disc being rounded and isolated. There is a circle of five pairs of plates round the centre of the abactinal side; from this circle series of four longitudinal rows of plates pass outward down each ray. The plates of the longitudinal series become crowded and subpolygonal at the distal end of the rays.

On the actinal side the interbrachial areas are covered with isolated, rounded, or subangular plates, bearing spines. The marginal plates are small and usually bear small spines. The presence of supramarginals is doubtful.

The adambulacral ossicles are boot-shaped, and the ambulacral groove is bordered by a series of large adambulacrals.

TYPE SPECIES.—*Palæasterina primæva* (Forbes), 1848.[2] Mem. Geol. Surv., vol. ii, pt. 2, p. 463; 1849, Dec. Geol. Surv., dec. i, pl. i, fig. 2. Ludlow Series: Underbarrow, Westmoreland.

PALÆASTERINA BONNEYI, n.sp. Pl. XVI, Figs. 2*a*, *b*.

DIAGNOSIS.

Rays short and blunt, tapering regularly; disc rounded or subpentagonal. The ratio of *R* to *r* is 2 : 1.

On the abactinal surface there are three longitudinal series of large plates, crowded distally, but separated by areas bearing smaller plates in the disc.

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[1] The references included in the above list show some of the limitations to which the genus must submit.

[2] Salter and J. de C. Sowerby in 1843 recorded an asterid from the Arenig beds as *Asterias primæva*, but apparently it was never described (Quart. Journ. Geol. Soc., vol. i, p. 8, and table i, opposite p. 21).

About 25 large, oblong adambulacral plates on each side of each ray. The adambulacrals bear small tufts of about three spines, and single spines occur on the plates of the actinal intermediate areas, which plates are numerous.

DISTRIBUTION.

Ludlow Shales: Leintwardine, Shropshire.

FIGURES.

Pl. XVI, Figs. 2*a* and *b*. Abactinal and actinal views of specimens in the Geological Survey Collection.

Fig. 1, abactinal surface of part of the disc and one ray, × 3 dia. Fig. 2, actinal view of a ray, × 4 dia. Figs. 3*a* and *b*, abactinal and actinal views of distal part of one ray.

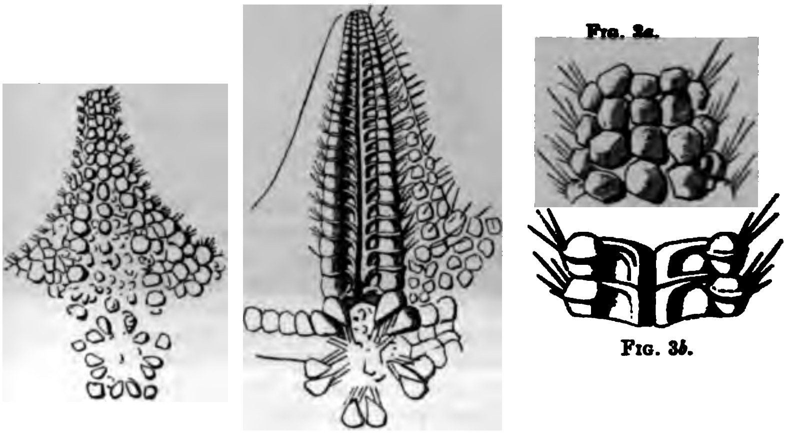

FIG. 3*a*.

FIG. 3*b*.

FIG. 1.

FIG. 2.

Palæasterina Bonneyi. Ludlow Shales: Leintwardine.

FIG. 1.—Abactinal surface of one ray, × 3 dia. FIG. 2.—Actinal surface, × 4 dia. FIGS. 3*a* and *b*.—Abactinal and actinal views of distal end of ray.

AFFINITIES.

This species has hitherto been included in *P. primæva*, the type species of the genus, from which it differs by having shorter and blunter rays, more numerous actinal interbrachial plates, and more adambulacral plates in each series; the character of the abactinal ray plates is also different in the species, the longitudinal series being widely separated at the proximal end of the rays in *P. Bonneyi*.

The species is of interest, as the structure is better preserved than in the type of the genus, and thus we are largely dependent upon it for our knowledge of the generic characters. These are well shown in the accompanying illustrations, which are prepared from the proofs of some unpublished drawings by J. W. Lowry.

2. SCHŒNASTER, Meek & Worthen, 1860.

Palæasterina, subgenus *Schœnaster*, Meek & Worthen, 1860: Proc. Acad. Nat. Sci. Phil., 1860, p. 449; and 1866, Geol. Surv. Ill., Palæont., vol. ii, p. 277.

TYPE SPECIES.—*Palæasterina* (*Schœnaster*) *fimbriata*, Meek & *Worthen*, 1860. Op. cit., p. 449; and 1866, op. cit., p. 278, *pl. xix, fig.* 7. Sub-Carboniferous: Illinois.

3. SCHUCHERTIA, nov. gen.

Diagnosis.

Palæasterinidæ with tessellate exoskeleton; the rays are short and the general shape is pentagonal. $R : r$ as 2 : 1. Interradial plates numerous, polygonal. Adambulacral plates large and hexagonal. Ambulacral furrow tapering uniformly toward the distal end.

Type Species.—*Palæasterina stellata*, Billings, 1858. Dec. Geol. Surv. Canada, No. iii, p. 76, pl. ix, fig. 1. Trenton Limestone: Ottawa.

Affinities.

Allied to *Palæasterina* by the general form of the body and the absence of the marginal plates. Billings clearly doubted whether the fossil could be left in *Palæasterina*, and he noticed the absence of the spines so conspicuous in the typical species of that genus. The general appearance of the species resembles *Lindstromaster*, from which it differs by the smallness of the marginal plates.

Family 3. ASPIDOSOMATIDÆ.

Diagnosis.

Phanerozonia with alternate ambulacral ossicles, large marginal ossicles, and extensive depressed interradial areas. Rays massive, petaloid, subpetaloid, or tapering.

1. ASPIDOSOMA, Goldfuss, 1848.

"Ein Seestern aus der Grauwacke": Verh. naturh. Ver. preuss. Rheinl., vol. v, pp. 145–6, pl. v.

Type Species.—*Aspidosoma Arnoldi*, Goldfuss, 1848. Op. cit. Lower Devonian: Germany.

2. PALÆOSTELLA, Stürtz, 1890.

"Neu. Beitr. palaeoz. Seest.": Palæontogr., vol. xxxvi, p. 230.

Type Species.—*Palæostella solida*, Stürtz, 1890. Op. cit., p. 230, pl. xxxi, figs. 42, 43. "Ueber verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 42, pl. i, figs. 6–8. Lower Devonian: Germany.

3. TRICHASTEROPSIS, Eck, 1879.

"Bemerk. zu Pohlig üb. Aspidura": Zeit. deut. geol. Ges., vol. xxxi, pp. 45, 265.

Type Species.—*Asterias cilicia*, Quenstedt, 1852. Handb. Petref., p. 596, pl. li, figs. 23, 24. *Trichasteropsis cilicia*, Eck, 1879. Op. cit., pp. 43, 265, pl. iv, fig. 3. Muschelkalk: Crailsheim.

Family 4. TÆNIASTERIDÆ.

Diagnosis.

Phanerozonia with alternate ambulacral ossicles. There is neither disc nor interbrachial area. Large marginal plates, of which the inframarginals act as the adambulacral ossicles. Rays long; petaloid or tapering gradually.

1. TÆNIASTER, Billings, 1858.

Dec. Geol. Surv. Canada, No. iii, p. 80.

Type Species.—*Tæniaster spinosus*, Billings, 1858. Op. cit., p. 81, pl. x, fig. 3. Ordovician: Canada. Not Tæniaster cylindrus, Billings (op. cit., p. 81, pl. x, fig. 4), which has been made the type of a genus of Ophiurids—*Tæniura*. (Gregory, "Classif. Palæoz. Ophiur.": Proc. Zool. Soc., 1896, p. 1,035.)

AFFINITIES.

The Tæniasteridæ are possibly nearly allied to the Stichasteridæ, which Sladen includes in the Cryptozonia. They are provisionally left in the Phanerozonia, until the character of the adambulacral plates can be definitely determined. The family is intermediate between the typical Phanerozonia and Cryptozonia.

?2. STENASTER, Billings, 1858.

Op. cit., p. 17.

TYPE SPECIES.—*Stenaster Salteri*, Billings, 1858. Op. cit., p. 78, pl. x, fig. 1. Ordovician: Canada. *Non S. pulchellus*, Billings (op. cit., p. 79, pl. x, fig. 2); *nec S. confluens*, Trautschold, Kalkbr. Mjatsch., pp. 109, 110, pl. xiii, fig. 5.

3. URASTERELLA, McCoy, 1851.

Brit. Palæoz. Foss., fasc. i, p. 59.

TYPE SPECIES.—*Uraster Ruthveni*, Forbes, 1848. "Brit. Foss. Aster.": Mem. Geol. Surv., vol. ii, pt. 2, p. 463. Silurian: Westmoreland.

AFFINITIES.

This genus includes the *Stenaster pulchellus*, Billings (op. cit., p. 79, pl. x, fig. 2). It has often been treated as synonymous with *Stenaster*, or merged in *Palæaster*. Thus Salter,[1] both in 1857 and 1873, included the type species of *Urasterella* and *U. hirudo* (Forbes) in *Palæaster*, whereas in 1859 he[2] included the latter in *Palæasterina*. In the former proposal he has been followed by most English authors, as, e.g., Etheridge,[3] De la Touche,[4] and Woods.[5]

4. PROTASTERACANTHION, Stürtz, 1886.

"Beitr. palaeoz. Seest.": Palæontogr., vol. xxxii, p. 90.

TYPE SPECIES.—*Protasteracanthion primus*, Stürtz, 1886. Op. cit., p. 90, pl. xi, fig. 3. Lower Devonian: Germany.

5. SALTERASTER, Stürtz, 1893.

"Ueber verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 42.

TYPE SPECIES.—*Palæaster asperrimus*, Salter, 1857. New Palæoz. Starf.: Ann. Mag. Nat. Hist., ser. 2, vol. xx, p. 325, pl. ix, fig. 1. Ordovician: near Welshpool, N. Wales.

Order 2. CRYPTOZONIA.

Family LEPIDASTERIDÆ.

DIAGNOSIS.

Cryptozonia which are heavily plated, but in which there are no special marginal plates. The ambulacral ossicles are alternate (or possibly sometimes opposite). The disc is large, and the rays short, thick, and blunt or clavate. There are no lateral spines. The abactinal plates are granular and closely set.

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[1] J. W. Salter, "New Palæoz. Starfishes": Ann. Mag. Nat. Hist., ser. 2, vol. xx (1857), pp. 325, 326. Also Cat. Cambr. and Sil. Foss. Cambridge, 1873, p. 163.

[2] In Murchison's "Siluria," 3rd ed., p. 248, fig. 56, No. 2.

[3] R. Etheridge: Pres. Add., Quart. Journ. Geol. Soc., vol. xxxvii (1881), Proc., p. 173.

[4] *De la Touche*: Handb. Geol. Shrops., p. 34.

[5] *H. Woods*: Cat. Type Foss. Woodw. Mus., p. 35.

1. LEPIDASTER, Forbes, 1850.

Dec. Geol. Surv., No. iii, pl. i.

TYPE SPECIES. — *L. Grayi*, Forbes, 1850. Op. cit. Wenlock Limestone: Dudley.

2. ETHERIDGASTER, nov. gen.

DIAGNOSIS.

Lepidasteridæ with five clavate arms. The arms are covered abactinally by three rows of alternating, hexagonal plates. The abactinal surface of the rays is occupied by the broad adambulacral ossicles. Ambulacral ossicles opposite (*fide* De Koninck).

TYPE SPECIES.—*Palæaster Clarkei*, De Koninck, 1877. Foss. Pal. Nouv. Galles des Sud., pt. iii, p. 166, pl. vii, figs. 6 and 6*a*. *Palæaster* (*Monaster*) *Clarkei*, R. Etheridge, jun., 1892. Mon. Carb. Invert. New South Wales, pt. ii, p. 71, pl. xiv, figs. 1, 2; pl. xv, fig. 4. Carboniferous: Farley and West Maitland, Northumberland County, New South Wales.

AFFINITIES.

The type species of this genus has been admirably figured and described by Mr. R. Etheridge, jun., after whom it is named. As *Etheridgia* and *Etheridgina* and probably other modifications of that surname are preoccupied, I follow the convenient *Salteraster* precedent.

Etheridge remarked that the starfish might have to be removed far from *Palæaster*, and even from the same order. From the absence of special marginal plates it appears to me advisable to include it in the Cryptozonia. It is allied to *Lepidaster* by the heavily-plated, blunt arms, large disc, and wide adambulacral plates.

Reference to the Lepidasteridæ renders it advisable to remark that the classification adopted in this paper is probably wrong in connection with this family or with the Tæniasteridæ. The former is included in the Cryptozonia, as it has no special marginal plates and the adambulacral plates are very wide (transversely to the arm) and resemble those of the Jurassic genus *Tropidaster*. It is possible that *Tropidaster* is a later representative of the Lepidasteridæ, in which the abactinal plates have broken up into an irregular set of granules.

But the Tæniasteridæ, in which the adambulacral plates act as marginals, and there is no special additional set of marginal ossicles, I have left in the Phanerozonia. It may, however, be urged that the Tæniasterids ought to go with the Lepidasterids. The reason why I have kept them apart is the idea that the adambulacral plates of Lepidasterids are true adambulacrals; whereas in the Tæniasterids these plates are rudimentary, and those described as adambulacrals are really marginal plates.

EXPLANATION OF PLATE XVI.

FIG. 1.—*Lindstromaster antiqua* (Hisinger), 1837.
,, 1*a*.—Outline of actinal surface of type-specimen, nat. size.
,, 1*b*.—The same magnified 4 diameters.
Bed C, corresponding to the Wenlock Shale, Gotland.
,, 2.—*Palæasterina Bonneyi*, sp. nov.
,, 2*a*.—Abactinal view of specimen, magnified 2 diameters.
,, 2*b*.—Actinal ,, ,, ,, 3 diameters.
Ludlow Shales: Leintwardine, Shropshire.

III.—A DISCUSSION ON THE USE OF THE TERMS ROCK-WEATHERING, SERPENTINIZATION, AND HYDROMETAMORPHISM.

By GEORGE P. MERRILL,
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IN the abstract of a paper by Mr. Thomas H. Holland, read before the British Association, Section C (Geology), Bristol, 1898, printed in the January number of this Magazine,[1] on "The Comparative Actions of Subaërial and Submarine Agents in Rock Decomposition," the author brings up again a question which the present writer has often had occasion to face, and has vainly tried to solve in a manner entirely satisfactory even to himself.

The question relates primarily to the limitation of the term weathering as applied to rocks, and indirectly to the general subject of hydrometamorphism and metasomatosis as manifested in the production of serpentine.

In my work on "Rocks, Rock-weathering, and Soils" (p. 174), is made the following statement:—

"The term weathering, as here used, is applied only to those superficial changes in a rock-mass brought about through atmospheric agencies, and resulting in a more or less complete destruction of the rock as a geological body, as where granitic rocks are resolved into sand and kaolinic material, with liberation of carbonates of the alkalies and of lime, and oxides of iron. It does not include those deeper-seated changes taking place below the zone of oxidation and which result mainly in hydration and the production, it may be, of new mineral species, as chlorite, sericite, zeolites, etc., but during which the rock-mass as a whole retains its individuality and geological identity. The distinction is not one that has been sharply insisted upon, and, indeed, geologists and petrologists as a rule have been extremely careless in their use of such terms as *alteration*, *decomposition*, and *weathering*. The distinction drawn here is essentially that made by Roth (Allgemeine u. Chemische Geologie) between *Verwitterung* and *Complicirte Verwitterung*. For reasons above stated and others given on p. 161, it seems best to limit the terms weathering and decomposition to processes involving the destruction of the rock-mass as a geological body, and to designate the purely mineralogical, deeper-seated changes, as alteration, which may or may not be due wholly to hydrometamorphism."

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[1] GEOL. MAG., January, 1899, pp. 30–1.

This is essentially the ground taken by Lindgren also,[1] and while it may be open to criticism, nothing better, so far as the writer is aware, has been suggested.

Let us take for purposes of discussion the serpentinization of the mineral olivine, as mentioned in the abstract of Mr. Holland's paper. The author states (p. 31):—"In all these cases, however, although the action of the atmosphere is so striking, the results are purely superficial, and a specimen of rock taken from within a few inches of the clay products seldom shows a trace of hydrous decomposition, even in thin sections under the microscope. This is just as true for such delicate minerals as olivine and nepheline as for the commoner silicates. In many of the basic dykes, certainly pre-Cretaceous and probably Lower Palæozoic in age, the absence of serpentine is so complete that unusual precautions are often necessary for the determination of the olivine, whilst in the numerous occurrences of dunite throughout the Madras Presidency serpentine is extremely scarce."

Mr. Holland would account for this wide difference in the conduct of the olivine in Indian and European localities on the supposition that the European areas had, during the later geological periods, been submerged below the sea, while in southern India there are no evidences of any such depression since Lower Palæozoic time.

Just what would be the effect of prolonged submergence in sea-water on a mass of olivine rock the writer is not prepared to say, but he does express the doubt if simple weathering of the mineral is ever productive of serpentine. Has there been ever advanced any proof that serpentinization is a superficial phenomenon? If due to weathering we ought somewhere to meet with masses which are superficially converted into serpentine and gradually resume their normal character at greater depths.

So far as is to be judged from available literature the olivine granules in any mass of rock, however dense, show no greater degree of hydration (serpentinization) near the surface or along contacts where surface waters would most readily permeate, than in the interior of the mass. Further than this, serpentinization is as common, so far as the United States is concerned, in the arid portions of the West as in the humid East. In fact, this phenomenon is apparently entirely independent of climatic conditions. Is not the inference, then, fair that the process has gone on entirely independent of surface waters?

Although convinced that excepting in the purely physical weathering of arid regions hydration is a most important factor,[2] the absence of any but a very narrow zone of hydration products between the residual clay and fresh rock is not at all strange. Much depends on the texture of the rock and its mineral composition. In cases where the weathering is largely in the nature of solution and oxidization such abrupt changes are to be expected. The Fourche Mt. syenite, of Arkansas, an almost purely feldspathic rock, passes within the space of 2 cm. from a fine red-brown unctious clay to a massive fresh unchanged feldspar: the nepheline of the nepheline syenite of Mias in the Urals is eaten out below the surface of the more refractory feldspar, mica, zircons, etc., but gives in the closed tube only traces of water and shows under the microscope only incipient stages of hydration.

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[1] 17th Ann. Rep. U.S.G.S., 1895–6, pt. ii, pp. 90–6.

[2] "Rocks and Rock-weathering," pp. 188, 234, etc.

My own view of the case is, that the two phenomena are due to widely different causes; that serpentinization is a deep-seated process due to waters or vapours coming from considerable depths, and it may be even constituents of the magmas at the time of their intrusion. The almost complete absence of oxidization products in fresh serpentine is indicative of this. Again, serpentinization is a process involving a greater degree of hydration than is weathering. The serpentinized olivine rock of the Nijni Tagilsk platinum district yields 14·21 per cent. of water, while the brown crust which results from its weathering yields but 11·74 per cent. The serpentine of Harford County, Maryland, further, shows a loss on ignition of 18·15 per cent.,[1] while the hard red-brown crust produced on the immediate surface, through weathering, loses but 11·82 per cent. and the residual soil but 7·89 per cent. In the same manner soils derived by weathering from other highly hydrated magnesian rocks, as the so-called soapstone (altered pyroxenites), show a very considerable loss of water, even though the actual loss on ignition in the resultant soil may be a trifle greater than in the fresh rock.

These facts are mentioned in detail here since they do not seem to have been before noted, or at least their significance not realized. If serpentinization were a product of weathering, a shorter exposure to atmospheric influences, as in India, ought to result in merely a thinner coating of serpentine over the altered material. Were it a result of subaerial agencies, certainly the superficial alteration of olivine into serpentine ought to be more nearly universal. Yet, in several instances, as notably in the corundum areas of western North Carolina, the olivine is almost perfectly fresh, but on the immediate surface rotted away to a ferruginous clay.

That this process of hydration, hydrometamorphism, or alteration, whichever term may be used, is quite distinct from true weathering, is further shown by the corundum crystals of this same region. These are often superficially or quite altered to damourite. Yet both the corundum and the alteration products are so resistant to weathering, that they remain among the residues in the clays resulting from the decomposition (weathering) of the mother rock, whatever that may have been. Serpentine pseudomorphs after pyroxene are sometimes more refractory than the rock in which they are formed, and may be found with well-preserved crystal outlines in the débris resulting from its breaking down.[2] When rocks like the Nijni Tagilsk peridotites, which are largely serpentinized but still contain residuary olivines, undergo actual weathering, the olivines do not yield serpentine, but break up, as does the serpentine itself into free iron oxides, free silica, carbonates of magnesia, and unrecognizable earthy products.

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[1] In part due to C O, though the amount of this constituent cannot be over 3 or 4 per cent.

[2] J. Smith, "Crystals from Decomposed Trap": Geol. Mag., Dec. IV, Vol. VI *(1899), p. 93.*

The ideas put forward in this paper are not altogether new, and are in part in harmony and in part in conflict with those advanced by others.

Thus Bischoff says:[1] "The decomposition of a rock takes place only when it is exposed to the undisturbed action of atmospheric agents; while alteration, on the contrary, takes place when the rock is more or less beyond the reach of this action." On the other hand, Roth,[2] to whom we owe so much, speaks of both serpentine and zeolites as products of weathering (*Verwitterung*), but in his latest work[3] he so far changes his views or mode of expressing them as to call the deep-seated process *Complicirte Verwitterung*, in distinction from the purely superficial *Verwitterung*, due to atmospheric action. Moreover, in the paper "Ueber den Serpentin," to which reference is made above, he describes the processes and results incidental to the *Verwitterung* of the serpentine quite independently of those incidental to its first production.

Teall[4] apparently accepts unhesitatingly ideas contrary to those expressed by myself, for he says: "The alteration of olivine by surface agencies—water, carbonic acid, and oxygen—gives rise to serpentinous and other pseudomorphs."

Consideration along these lines led the present writer in the work to which reference has been made to attempt making a distinction between true weathering and the more deep-seated process which he called hydrometamorphism. Surely processes so widely different as those resulting in the production of a serpentine from a peridotite and the final destruction through oxidation, carbonization, and partial dehydration of this same serpentine, should not be confounded under the same name. The distinction, it is true, is not one that can at all times be readily made. As the petrologist finds difficulty in separating his plutonic from the effusive rocks, so here are no hard and fast lines, and it is often impossible to state at just what point one shall assume that superficial processes cease and the deep-seated begin. The writer's conclusions are to the effect that the zone of oxidation forms the natural and easiest recognizable limit. The processes within this zone are those of weathering; those below, whether brought about by superficial waters deprived of their free oxygen and carbonic acid, or by deep-seated waters welling upwards, are those of hydrometamorphism, metasomatosis, alteration, or whatever suitable name may be adopted.

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[1] "Chemical and Physical Geology," Paul & Drummond's English translation, 1854, vol. iii, p. 86.

[2] "Über den Serpentin, etc.": Abhandl. der K. Akademie der Wiss. zu Berlin, ii (1869), p. 42.

[3] "Allegemeine u. Chemische Geologie," 1893.

[4] "British Petrography," p. 85.

In conclusion, one might urge the necessity of closer observations regarding the formation of serpentine from olivine or other anhydrous magnesian silicates. That it is through a process of hydration is self-evident, but as to the conditions under which it goes on literature is strangely silent. Is the process still going on in the exposed masses now open to our inspection, or is it at a standstill? The writer is of the present opinion that both this process and that resulting in the formation of zeolites and chlorites have ceased, so far as material available for study is concerned. They are due to conditions which do not exist on the immediate surface, except it may be in such sporadic and unusual occurrences as those of Plombieres, or those more recently described by F. Gonnard[1] and by Lacroix.[2] This paper is, however, written more for the purpose of eliciting the opinions of others than of expressing those of the writer.

IV.—WOODWARDIAN MUSEUM NOTES: A NEW TRILOBITE FROM MOUNT STEPHEN, FIELD, B.C.

By F. R. COWPER REED, M.A., F.G.S.

A REPRESENTATIVE collection of fossils from the Middle Cambrian beds of Mount Stephen, Field, British Columbia, has recently been brought back by Mr. S. H. Reynolds, M.A., F.G.S., and presented to the Woodwardian Museum. The fauna has been described by Rominger[3] and Walcott[4]; and the latter[5] has compared it to that from the Highland range, near Pioche, Nevada, and from near Antelope Spring, Western Utah. The section at Field has been described by Mr. R. G. McConnell.[6]

The collection made by Mr. Reynolds contains the following species:—

Ogygopsis Klotzi (Rominger).
Ogygopsis, sp.
Bathyuriscus Howelli (Walcott).
Olenoides nevadensis (Meek).[7]
Olenoides cf. *quadriceps* (Hall & Whitfield).
Ptychoparia Cordilleræ (Rominger).
Ptychoparia, sp.

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[1] Bull. de la Société Minéralogique de France, vol. v (1882), p. 268.

[2] Comptes Rendus Paris Acad. Sci., vol. xxiii (1896), p. 761.

[3] C. Rominger, "Description of Primordial Fossils from Mount Stephens, North-West Territory of Canada": Proc. Acad. Nat. Sci. Philadelphia (1887), p. 12, pl. i.

[4] C. D. Walcott, "Cambrian Fossils from Mount Stephens, North-West Territory of Canada": Amer. Journ. Sci., ser. III, vol. xxxvi (1888), p. 163. "Descriptions of New Genera and Species of Fossils from the Middle Cambrian": Proc. U.S. Nat. Mus., vol. ii (1889), p. 441.

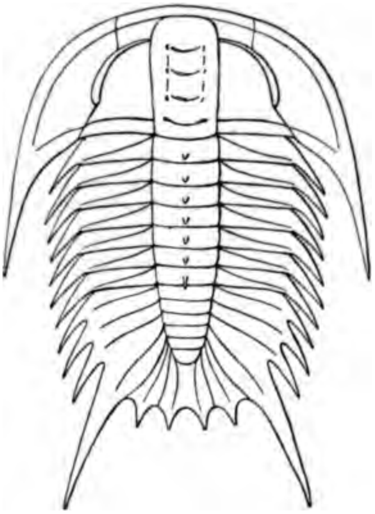
[5] Correlation Papers, Cambrian: Bull. U.S. Geol. Surv., No. 81 (1891), pp. 170–1, 326–7, 360–1, 366, and pl. ii.

[6] Geol. Surv. Canada, new ser., vol. ii (1886–7), pp. 24D–30D.

[7] Matthew (Trans. Roy. Soc. Canada, ser. II, vol. iii (1897), sect. iv, No. 7, p. 186) contends that Dames' name *Dorypyge* (Dames in Richthofen's "China," iv: Beitr. z. Paläont., 1883, p. 23, t. i, figs. 1–6) has the priority of *Olenoides*. Matthew here describes a variety of *Olenoides* (*Dorypyge*) *quadriceps* from the St. John Group of Hastings Cove.

Agnostus interstrictus (White).
Oryctocephalus Reynoldsi, n.sp.
Acrotreta gemma (Billings).
Kutorgina pannula (White).
Lingulella ella (Hall & Whitfield)?
Scenella cf. *varians* (Walcott).
Hyolithes, sp.

All the above trilobites have been recorded previously with the exception of *Olenoides* cf. *quadriceps* and *Oryctocephalus Reynoldsi*, n.sp., the latter of which I have much pleasure in naming in honour of its discoverer. The specimen is of peculiar interest as it consists of a complete individual in perfect preservation, whereas our previous knowledge of the genus has been restricted to the disconnected head-shields and pygidia of *Orycto. primus* described by Walcott.



Restored outline of *Oryctocephalus Reynoldsi*, sp. nov. Middle Cambrian: Mount Stephen, Field, British Columbia. Magnified about four times natural size.

Oryctocephalus Reynoldsi, n.sp.

Head-shield transversely semicircular, broad, short, more than twice as broad as long. Glabella elongate, cylindrical, sides parallel[1]; reaches margin; front rounded; surface marked by four pairs of transverse furrows. The three anterior pairs of transverse furrows are equidistant, and terminate in small deep pits within the margin of the glabella; each furrow is shallow and arches slightly backwards in the centre. A shallow groove parallel to the axal furrow connects the pits on each side longitudinally. The fourth transverse furrow crosses the base of the glabella at a distance from the third furrow rather greater than the latter from the second or the second from the first, and is stronger and deeper than the others, but similarly does not reach the axal furrows, terminating on each side in an elongated pit within them. and thus marking off incompletely the strong rounded occipital ring. Axal furrows straight and strongly defined.

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[1] Owing to slight crushing the glabella in our specimen appears to be slightly wider in front than at the base.

Fixed cheeks nearly as broad as glabella behind ocular ridge, but narrower in front of it. No frontal limb present, as glabella reaches margin. Margin narrow, raised, and rounded, with concentric striations on lower surface. Palpebral lobe arched outwards, narrow, long, with a groove separating it from fixed cheeks. Ocular ridge narrow, continuous with palpebral lobe and touching glabella just in front of anterior transverse furrow.

Free cheeks narrow, slightly longer than fixed cheeks and reaching further back, furnished with narrow raised margin, produced at genal angles into long straight spines obliquely directed outwards and backwards and nearly as long as the thorax.

Neck-furrow at base of cheeks strong, makes a sudden short backward bend where it crosses from the fixed on to the free cheek; neck-ring narrow.

Thorax composed of seven segments; narrower than the head-shield, being only the width of the 'middle-shield.' Axis cylindrical, expanding slightly in width towards the middle, then gradually tapering to the pygidium; narrower than pleuræ on each side. Axal furrows deep. Axial rings rather wide, each possessing median, slender, short spine (crushed down on body-ring or broken off); the spine on the last one is longer than the others.

Pleuræ wider than axis, flattened and horizontally extended and in close contact for three-fourths of their length, beyond which point they become free, are slightly bent downwards and backwards, contracting rapidly into slender, rounded, sharp spines. Each pleura is marked with a strong diagonal furrow curving backwards from the inner anterior angle on the axal furrow to the base of the spine.

Pygidium large, nearly as long as thorax, wider than long, with straight anterior edge; composed of six segments. Axis long, narrow, conical, obtusely pointed, consisting of five complete rings and a small terminal segment, marked off by regular transverse furrows. The axis does not reach the posterior margin, being only about two-thirds the length of the pygidium. Lateral lobes composed of six fused pleuræ. The first three are of equal size and preserve nearly the same width for their whole length, but end in finely pointed slender spines projecting freely beyond the margin and directed obliquely backwards, similar to those of the thoracic pleuræ. Each pleura is also marked by a strong diagonal furrow, but the interpleural furrows are almost obsolete, so that the pleuræ appear fused together. The fourth pair of pleuræ are of the same width at their base as the preceding ones, but expand towards the pygidial margin, beyond which they taper into long free stout spines directed backwards and slightly outwards, parallel to the spines of the first three pleuræ but at least three times their length, giving a distinctive and striking appearance to the pygidium. A strong diagonal furrow crosses each of these fourth pleuræ, but is not continued on to the free spine. The separation of this pair of pleuræ from the fifth pair is well marked by distinct interpleural furrows.

The fifth pair of pleuræ, which are short and wider towards their extremity than at their base, are directed backwards and slightly outwards, ended in short rounded spines projecting freely beyond the margin. The sixth pair of pleuræ are fused together in the middle line directly behind the axis, but are separated by a well-marked furrow from the preceding pair, which they resemble in shape. They are directed straight backwards, and end in short rounded spines of the same size as those of the fifth pair and likewise projecting freely beyond the margin. The strong diagonal furrows of this sixth pair of pleuræ are parallel to each other, and run down the centre of each pleura to the base of the spine.

MEASUREMENTS.

	mm.
Length of specimen	17·5
,, head-shield	6·0
,, thorax	6·5
,, pygidium	5·0
Width of head-shield	14·5
,, thorax (front end)	9·5
,, pygidium	8·5

Affinities.—There has been only one species (*O. primus*, Walcott)[1] described belonging to this genus, and to this form *O. Reynoldsi* bears a very close resemblance. The head-shield offers scarcely any points of difference, but the palpebral lobes of our new form are longer, and the genal spines are also more elongated. The thorax of Walcott's species is unknown. The pygidium of our form differs by its shorter axis not reaching the posterior margin, by the possession of six instead of five pairs of pleuræ, by their diagonal furrows and by the relative development of their free pointed extremities. The number of segments in the axis is, however, the same, and the freely projecting points of the pleuræ with the reduced length of the last pair behind the axis give a general appearance of similarity.

Though the head-shield shows such distinct and unique features, particularly in the lobation of the glabella, the resemblance of the pygidium to that of several species of *Olenoides* (*O. quadriceps*, Meek, *O. wahsatchensis*, Hall & Whitfield, *O. Fordi*, Walcott) deserves notice. The pleuræ recall those of *Paradoxides*, while the spinose rings of the axis remind one of *Olenoides* (*Zacanthoides*) *typicalis* (Walcott) and *O. nevadensis* (Meek).

Oryctocephalus primus (Walcott) is found in the Middle Cambrian Limestone, east of Pioche, Nevada,[2] but so far as I know the genus has not been recorded elsewhere.

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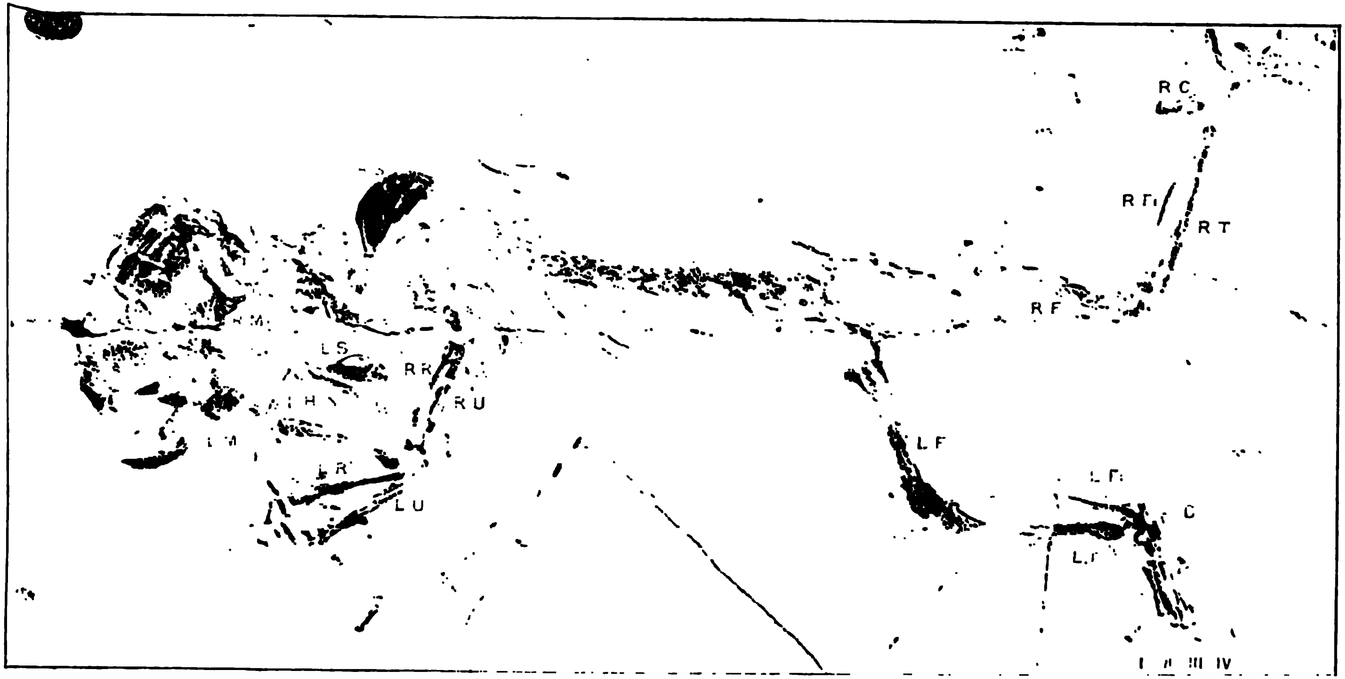
[1] Bull. U.S. Geol. Surv., No. 30 (1886). "Cambrian Faunas of North America," pt. 2, p. 210, pl. xxix, figs. 3, 3*a*: Tenth Ann. Rep. U.S. Geol. Surv., 1888. "The Fauna of the Olenellus Zone," p. 663, pl. xcv, figs. 4, 4*a*.

[2] Walcott: Bull. U.S. Geol. Surv., No. 30 (1886), p. 210.



Skeleton of *Sanias Bredai*, H. v. Meyer, 1848.

Middle Miocene, Oeningen, Southern Germany. Two-thirds natural size.

V.—SOME RODENTS FROM THE MIDDLE MIOCENE LACUSTRINE DEPOSITS OF OENINGEN, SOUTHERN GERMANY.

By Dr. C. I. FORSYTH MAJOR, F.Z.S.

(PLATE XVII.)

IN the Geological Department of the British Museum (Natural History) are preserved a certain number of slabs from Oeningen, exhibiting skeletons of Rodents. Partly owing to unskilful developing, partly to the absence of the counterpart-slab, several of them are in such a crushed and otherwise imperfect condition, that in some cases not even the genus could be made out with certainty; which is equivalent to saying that their interest is little beyond that of mere curiosities. On closer examination it appeared to me that in some instances the case was not quite so hopeless, and that by carefully developing the more important parts still concealed by the matrix, a more satisfactory state of things might be obtained. The following pages are an account of the result arrived at.

The splendid series of Oeningen Fossils in the British Museum (Natural History) formed part, with a few exceptions, of Professor van Breda's collection in Haarlem, which was purchased of the Executors of Dr. de Haan, his son-in-law, in 1871 by the Trustees of the British Museum. Dr. Henry Woodward informs me that most, if not all, of these specimens were collected in the quarries of Oeningen by Oswald Heer, when a young man struggling to pay his own college fees at the University, and by him transmitted for purchase to Professor van Breda. (See Obituary of Prof. O. Heer, GEOL. MAG., 1883, Dec. II, Vol. X, p. 576.)

1. SCIURUS BREDAI, H. v. Meyer.

Sciurus Bredai, H. v. Meyer: Neues Jahrbuch, p. 472 (1848); Schlosser, Die Nager des europäischen Tertiärs, Palaeontographica, xxxi, p. 88 (1884).

Sciurus spermophilinus, Depéret: Arch. Mus. Lyon, iv, p. 152, pl. xiii, figs. 14, 14*a* (1887); v, p. 48, pl. i, figs. 26, 27 (1892); Forsyth Major, Proc. Zool. Soc. London, p. 193, pl. x, figs. 4–9 (1893).

The only reference made by H. v. Meyer to this name is to the effect that it refers to a new species of *Sciurus*, from Oeningen, and preserved in the van Breda Collection at Haarlem.[1]

Amongst the MSS. of H. v. Meyer, deposited in the Munich Palæontological Museum, Schlosser came upon a rough ('flüchtige') sketch of the specimen, representing the mandible, scapula, humerus, and hind-limbs; he was thus enabled to give the following measurements (in millimetres): scapula, 16?; humerus, 26·5; femur, 34; tibia, 36; metat. iii, 12; diastema between incisors and premolar, 6; length of cheek-teeth, 7 (p.—m. 2, 5·4). Schlosser adds that the limbs are remarkably short as compared with the length of the teeth-row, and that the species may be identical with one of the *Sciurus* species from Sansan.[1]

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[1] ". . . . das erste Stück, welches ich in der reichen Sammlung des Professors van Breda erblickte, war ein neuer Nager von Oeningen, dem ich den Namen *Sciurus Bredai* beigelegt habe." (Neues Jahrb., p. 472, 1848.)

Several years afterwards, '*Sciurus Bredai*' is by the same author, without justification, given as a synonym of *Sciurus Gervaisianus*, Lart., from Sansan, and of *Sciurus spermophilinus*, Dep., from La Grive-Saint-Alban (Isère).[2]

To this identification Depéret rightly observes[3] that there is no sufficient reason for the assumption of specific identity between *Sc. Bredai* and *Sc. spermophilinus*; in fact, dimensions *alone* are a very unsafe criterion to rely upon for specific distinction or identification. The same must be said of *Sc. Gervaisianus*, Lart., from Sansan, which might come into consideration as a synonym of *Sc. Bredai*, since both Lartet and Gervais state it to be smaller than *Sc. vulgaris*, wherein it agrees with the Oeningen squirrel. But no other characters are given of the Sansan fossil, and Filhol, in his monograph of Sansan,[4] says that he is unacquainted with the specimens mentioned by his predecessors.

In the "Catalogue of the Fossil Mammalia in the British Museum (Natural History),"[5] Lydekker refers to the specimen No. 42,826, from Oeningen, in the following words:—

"*Sciurus*, sp. (cf. *S. bredai*, H. v. Meyer).

42,826. The much crushed skeleton of a rodent, probably belonging to the present genus, from the Upper Miocene of Oeningen, Switzerland. It is not improbable that this specimen, which indicates an animal rather smaller than *S. vulgaris*, may belong to Meyer's ill-defined *S. bredai*, which Schlosser suggests may be identical with one of the Sansan species. Van Breda Collection. Purchased 1871."

Both Schlosser, in 1884, and Depéret, in 1892, state that the type of *Sciurus Bredai* is at Haarlem; there can be no doubt, therefore, that it is the No. 42,826, which has been incognito in the British Museum (Natural History) since 1871, when the van Breda Collection was purchased "from the executors of Dr. de Haan, of Haarlem."[6] My reasons for this assumption are very obvious, for:

(1) No. 42,826 is the only specimen of *Sciurus* from Oeningen in the van Breda Collection.

(2) The bones mentioned and measured by Schlosser, after H. v. Meyer's sketch of the type, are present in the British Museum specimen, and in such a condition that the measurements published by Schlosser could be taken from them. The slight divergences between the latter author's measurements and my own are sufficiently explained by the fact that the former were not taken from the original but from a rough sketch, and that my accurate measurements

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[1] Palaeontographica, xxxi, p. 88 (1884).

[2] Beitr. Pal. Oestr.-Ung., viii, pp. 470, 471 (1890).

[3] Arch. Mus. Lyon, v, p. 50 (1892).

[4] H. Filhol, "Études sur les Mammifères fossiles de Sansan": Ann. Sci. Géol., xxi, 20, No. 1, pp. 38, 39 (1891).

[5] Part i, p. 211 (1885).

[6] *Cat. Foss.* Mamm., i, p. xii.

could only be taken after some of the bones had been fully developed. They are as follows:—

	mm.
Scapula	20·5
Humerus	26
Ulna	28
Femur	32·5
Tibia	37
Metat. iii	13
Calcaneus	13·5
Lower p.—m. 2	6

I must postpone the description of the limb-bones for a future opportunity, when limb-bones of recent species, it is hoped, may be available for comparison. The characters of the teeth come in the first line for a comparison with other Miocene squirrels. When the lower incisor of the Oeningen fossil was laid bare, it revealed a longitudinal striation of the enamel; this peculiarity, by itself, at once settles the question as to the affinities of the Oeningen squirrel. In the *Sc. spermophilinus*, Dep, from La Grive, I have described and figured the same character of the lower incisors;[1] so that the identity of the La Grive species with *Sc. Bredai* is fairly established.

The lower molars in the Oeningen specimen are unfortunately much worn and m. 3 is missing, so that I am unable to verify two other characters which I have described in *Sc. spermophilinus* and by which it agrees with some Oriental squirrels, viz., the great elevation of the antero-internal cusp and the elongation of m. 3.

2. LAGOPSIS VERUS (Hensel).

Lagomys Oeningensis, H. v. Meyer: Neues Jahrbuch, p. 58 (1836); p.p.; id., Fossile Säugethiere, etc., von Oeningen, p. 6, pl. iii, fig. 1 (1845); Biedermann, Petref. aus d. Umgegend von Winterthur, II, Die Braunkohlen von Elgg, p. 13, pl. iii, figs. 1–3 (1863); Lydekker, Cat. Foss. Mamm. Brit. Mus., i, p. 256 (1885), specim. No. 42,815 (42,816?, 42,820?).

Lagomys verus, Hensel: Zeitschr. deutsch. geol. Ges., viii, p. 688, pl. xvi, figs. 12, 13 (1856); Depéret, Arch. Mus. Lyon, iv, p. 164, pl. xiii, figs. 16, 17 (1887).

Titanomys visenoviensis, H. v. Meyer: Palaeontogr., xvii, p. 228 (1870); p.p.

Lagomys (*Lagopsis*) *Oeningensis*, Schlosser: Palaeontogr., xxxi, p. 13 (1884); p.p.

Lagomys (*Lagopsis*) *verus*, Schlosser: op. cit., p. 13, pl. xii, figs. 40, 46, 49 (1884); Depéret, Arch. Mus. Lyon, v, p. 57 (1892); p.p.

Laurillard was the first to recognize that lagomorphous Rodentia occur at Oeningen,[2] whereas a specimen in the British Museum, previously figured by König, had been assigned by the latter to the genus *Anœma*, under the name of *Anœma Oeningensis*.[1]

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[1] P.Z.S., p. 191, pl. x, fig. 5 (1893).

[2] R. I. Murchison, "On a Fossil Fox found at Oeningen, near Constance, etc.": Trans. Geol. Soc. London, iii, 2, p. 285 (1832). "Another animal of this order [i.e. Rodentia] was brought from the quarries this year by Professor Sedgwick, which M. Laurillard, of the Jardin du Roi, Paris, refers to *Lagomys*."

In his first note on the *Lagomys*-like Rodents of Oeningen, Hermann von Meyer was not aware that more than one form is represented in the deposit; accordingly, he comprises all the specimens under the name *Lagomys Oeningensis*.[2] Later on, in his monograph of the fossil Vertebrates of Oeningen,[3] he arbitrarily sets aside König's specific name of the smaller form, for which he adopts a manuscript name by Von Tschudi, founded on one of the labels, and applies the name *Lagomys Oeningensis* to the larger-sized specimens.

In a memoir read before the Linnean Society, and which will be published about the same time with the present note, I have at length dealt with the smaller form, whose proper name will be *Prolagus Oeningensis* (Kön.), but with which we have not to deal here. However, the Oeningen specimens of Rodents under examination having, from their unsatisfactory condition, occasioned much of the prevailing confusion, it is necessary before making an examination of the fossil in the British Museum, which I have determined as *Lagopsis verus*, to glean whatever additional information we are able from other fossils of the same and contemporaneous deposits.

Two skeletons from Oeningen are ascribed to '*Lagomys Oeningensis*' in the "Fauna der Vorwelt"—one from the Carlsruhe Museum, on pl. ii, fig. 1; the other from the Seyfried Collection at Constance, on pl. iii, fig. 1. Both agreeing approximately in size, H. v. Meyer assumes as a matter of course that they belong to the same species. The former specimen affords no evidence as to the important characters of the number and form of the cheek-teeth. In the latter the number of the lower cheek-teeth is given as four, the writer adding that neither is the posterior tooth tripartite as in recent species of *Lagomys*, nor does the shape of its alveolus favour such an assumption. H. v. Meyer was under the erroneous belief that the recent *Lagomys* had only four lower cheek-teeth, the posterior one complicated by the addition of a third lobe. As a matter of fact all the members of the recent genus *Lagomys* have five lower cheek-teeth, the fourth being bipartite like the two preceding it in the series, whilst the fifth is a small simple cylinder.

The insufficient acquaintance with the dentition of *Lagomys* prevented H. v. Meyer from investigating if perchance in the Seyfried specimen there was an alveolus for a fifth cheek-tooth. This omission and the error by which it was engendered have both proved fatal.

H. v. Meyer's error as to the number of teeth in *Lagomys* was set right by Hensel[4]; the former author was thereby induced to transfer his '*Lagomys Oeningensis*' to the genus *Titanomys*,[1] assuming, erroneously again, this latter genus alone to be characterized by four lower cheek-teeth only, the posterior of which is bipartite.

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[1] König: Icones Foss. Sect., pl. x, fig. 126 (1825).

[2] Neues Jahrbuch, p. 58 (1836).

[3] H. v. Meyer: "Zur Fauna des Vorwelt, Fossile Säugethiere, Vögel und Reptilien aus dem Molasse-Mergel von Oeningen," p. 7 (1845).

[4] *Zeitschr.* deutsch. geol. Ges., viii, p. 698 (1856).

Meanwhile a real step forward had been made by Hensel, in describing his '*Lagomys verus*,'[2] which was founded on a fossil communicated to him by Quenstedt; its provenance is not "aus den Bohnerzen der schwäbischen Alp," but from the Molasse of Althausen, Württemberg.[3] The species is based on the fragment of a mandibular ramus, and exhibits, in opposition to '*Myolagus*' (= *Prolagus*), described in the same article, five lower cheek-teeth, the posterior one being a small cylindriform tooth, as in the recent *Lagomys*; the anterior one is, also as in the latter, composed of only one cylinder, but of a more complicated pattern than in *Lagomys*.

Hensel's *Lagomys verus* having the size of H. v. Meyer's *L. Oeningensis*, and both localities being of the same geological age, the suspicion naturally arises that the two names might be synonyms. Hensel does not discuss this side of the question, and he could not do so; for, as he rightly says, the specimens of *L. Oeningensis* of the "Fauna der Vorwelt" are insufficiently characterized.

In his "Nager des europäischen Tertiärs,"[4] Schlosser enumerates '*Lagomys* (*Lagopsis*) *Oeningensis*, H. v. Mey.,' as distinct from '*Lagomys* (*Lagopsis*) *verus*, Hens.,' and the same course is followed by Zittel.[5] However, the former writer, when describing in the same memoir[6] specimens from other localities, suggests that after all '*Lagomys Oeningensis*,' from Oeningen, may be identical with *L. verus*, Hens. Three more or less complete mandibular rami from Deggenhausen, Elgg, and Hohenhöven respectively, had been mentioned by H. v. Meyer, and drawings of their teeth, found amongst his MSS., have been reproduced by Schlosser.[7] They show an agreement in their p. 2 with Hensel's *Lagomys verus*, and Schlosser therefore concludes[8] that they are the same species. He also proposes[9] to raise Hensel's *Lagomys verus* to generic rank—*Lagopsis*—chiefly on account of the difference from the recent *Lagomys* in the lower anterior premolar (p. 2).

Like the Oeningen '*Lagomys Oeningensis*,' no last molar (m. 3) is to be seen in the specimens from the three localities mentioned. Schlosser does not attach any great weight to the absence of this small tooth in the three specimens figured from H. v. Meyer's MSS. Neither do I; but for different reasons from those given by the former writer in the following passage, and with which

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[1] Palaeontographica, xvii, p. 228 (1870).

[2] Loc. cit., p. 688.

[3] Quenstedt: Handbuch d. Petrefaktenkunde, 2te Aufl., p. 45, fig. 6te (1867); id. H., 3te Aufl., p. 55, fig. 7 (1885).

[4] Palaeontographica, xxxi, p. 31 (1884).

[5] Handbuch d. Palaeontologie, iv, p. 553 (1891–93).

[6] Loc. cit., p. 32.

[7] Loc. cit., p. 31, pl. viii, figs. 40, 46, 49.

[8] Loc. cit., pp. 31, 32.

[9] Loc. cit., pp. 28–31.

I completely disagree: "Auf das Fehlen des letzten einfachen Backzahnes bei den drei von H. v. Meyer gezeichneten Exemplaren darf wohl nicht allzuviel Gewicht gelegt werden. Es ist nicht unmöglich, dass auch hier, wie bei *Titanomys visenoviensis*, im normalen Kiefer nur drei zweilobige Molaren vorhanden sind und dass daher der stiftförmige m. 4 [meaning m. 3] des Hensel'schen Originales als Analogon des bei *T. visenoviensis* abnorm vorkommenden Lobus des m. 3 [meaning m. 2] betrachtet werden muss."[1] This whole statement is somewhat vague and obscure; the writer seems to assume (1) that in *T. visenoviensis* both the m. 3 and a third posterior lobe of m. 2 occur only abnormally; and (2) that in '*Lagomys verus*' the presence of a m. 3 is likewise an abnormal occurrence. From these two assumptions the inference is drawn that in the type of *Lagomys verus* m. 3 is the 'analogue' of the equally 'abnormal' third lobe in m. 2 of *Titanomys visenoviensis*. The writer concludes by saying that he is almost inclined to consider the presence of m. 3 as a juvenile character, and that this tooth is caducous ('hinfällig'). This is very probably true with regard to *Titanomys visenoviensis*, and I have myself suggested it in the memoir in course of publication. The last lower molar of '*Lagomys verus*' is caducous after a manner, viz., it has often dropped out in the fossil, its alveolus being filled with matrix. But, as I shall show hereafter, it is decidedly erroneous to consider this tooth as caducous in the sense attached by Schlosser to this term; and so are all the other suggestions tentatively put forward in the passage quoted above.

Schlosser seems not to have had access to a publication by Biedermann in which '*Lagomys Oeningensis*, H. v. Mey.,' from the lignites of Elgg, near Winterthur (Switzerland), is described and figured.[2] The description is somewhat insufficient, and so are the figures, the details of the triturating surface of the molars not being described or represented. Still, enough is given to allow of a definite conclusion. A fifth lower molar is said to be present, smaller than in *Lepus*, and not, as in the latter, composed of two columns or prisms. The two upper figures of mandibular rami in figs. 2 and 3, pl. iii, which represent clearly the outer side, show in the anterior cheek-tooth (p. 2) two lateral grooves, which are characteristic of this tooth of *Lagopsis verus*. This character, as well as the evident rootless condition of the cheek-teeth, enables us to exclude at least the figured specimen of *Titanomys Fontannesi* (Dep.), which might otherwise need consideration, being of about the same size as *Lagopsis verus* and also on account of its occurring elsewhere associated with the latter. In one of his two splendid memoirs on the Miocene Vertebrates of the Rhône Basin, Depéret has described and figured, from the Middle Miocene of La Grive-Saint-Alban, a mandibular ramus exhibiting the characteristic anterior premolar of Hensel's *Lagomys verus*, and provided besides with the fifth simple molar.[1] I have myself collected at La Grive about half a dozen mandibular rami of the same Rodent, in all of which either this fifth tooth itself or its very distinct alveolus is present.

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[1] Loc. cit., p. 32.

[2] W. G. A. Biedermann: Petrefacten aus der Umgegend von Winterthur, 2tes *Heft, Die Braunkohlen von Elgg*, p. 13, pl. iii, figs. 1, 2, 3 (1863).

The foregoing observations mark another step in advance, for they show conclusively that the fifth lower molar of *Lagopsis verus* does not occur 'abnormally,' but that it is a characteristic feature of the species, as it is also in the recent *Lagomys*.

The upper cheek-teeth of *Lagopsis verus* are unknown up to the present. Depéret has published from La Grive a left palate devoid of teeth, but exhibiting very distinctly the alveoli of the five cheek-teeth; he assigns this fossil, quite rightly in my opinion, to *Lagopsis verus*.[2] At the same time he figures and describes the left palate of '*Lagodus Fontannesi*,'[3] in which two cheek-teeth are preserved; in the memoir alluded to above, I have arranged the latter under the genus *Titanomys*—*T. Fontannesi* (Dep.). No mandibles of this '*Lagodus Fontannesi*' are mentioned in Depéret's first memoir quoted, nor in the later one.[4] This circumstance seems to be the reason which has induced Schlosser to suggest that *Lagopsis verus* and '*Lagodus Fontannesi*' are the same species;[5] and, unfortunately, Depéret, in his second memoir,[6] inclines towards the same opinion, and has consequently omitted *Lagodus Fontannesi* from his latest list of the Vertebrates of La Grive,[7] *Lagomys verus* alone being mentioned. It may be asked, what then becomes of the left palate represented in the above-mentioned fig. 17 of Depéret's first memoir, which both writers overlook entirely when they unite together the two so widely different forms of *Lagopsis verus* and *Titanomys Fontannesi*. It is somewhat surprising that, according to Depéret,[8] more than fifty mandibular rami of *Lag. verus* have been found at La Grive, whilst not a single one of *Tit. Fontannesi* is mentioned; and I therefore venture to suggest that the mandibles of *Titanomys Fontannesi*, which are approximately of the same size as those of the other form, have not been recognized amongst the numerous rami collected. I have myself collected at La Grive over twenty mandibular rami, half-a-dozen of which belong to *Lagopsis verus* and seventeen to *Tit. Fontannesi*. Both are figured and described elsewhere, and I will therefore only briefly mention here that, apart from the difference in the cheek-teeth, the anterior premolar being the most important in this respect, the two genera present some difference in the shape of the bone as well. The horizontal ramus of *Tit. Fontannesi* is lower and more elongate;

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[1] Arch. Mus. Lyon, iv, p. 164, pl. xiii, figs. 16, 16*a* (1887).

[2] Loc. cit., p. 164, pl. xiii, fig. 17.

[3] Loc. cit., p. 171, pl. xiii, fig. 19.

[4] "La Faune des Mammif. mioc. de La-Grive-Saint-Alban": Arch. du Mus. d'Hist. Nat. de Lyon, v (1892).

[5] Beitr. Pal. Östr.-Ung., viii, pp. 86, 87 (1891).

[6] Loc. cit., p. 58.

[7] Depéret, "Sur la Classification et le Parallélisme du Système Miocène": Bull. Soc. Géol. France, xxi, p. 206 (1893).

[8] Arch. Mus. Lyon, iv, p. 164 (1887).

the diastema between the anterior premolars and the incisors is longer than in *Lagopsis*, and the inferior outline of the ramus, when viewed from the external side, is straighter in *Titanomys*.

Of upper cheek-teeth, which I feel entitled to ascribe to *Lagopsis verus*, I have found two amongst the fossils of La Grive (Brit. Mus. Geol. Dep., M. 5,264). The median of the three upper premolars of the recent *Lagomys*, p. 2, is characterized by a crescent enamel-folding, which opens freely on the outer margin of the tooth, near its anterior angle.[1] *Lagopsis* being the one Tertiary genus which in the form of its lower teeth comes nearest to *Lagomys*, it might be anticipated that the upper teeth of the fossil would likewise show a near approach to the recent *Lagomys*. In fact, one of the isolated teeth just mentioned, from La Grive, exhibits the same somewhat triangular outline, the apex being turned outwards, as the second upper premolar of *Lagomys*, and about the same characteristic enamel folding. It can therefore with certainty be determined as p. 2 of *Lagopsis*; I have described and figured it elsewhere. It can at once be distinguished from p. 2 of *Prolagus Oeningensis* (Kön.), occurring in the same deposits: in *P. Oeningensis* this tooth is much smaller, has a triangular outline with the apex turned inwards, and has a second enamel crescent, smaller than the one corresponding to the single one in the tooth of *Lagopsis*, and situated externally to it. The upper p. 2 of *Titanomys Fontannesi*, which approaches nearer in size to *Lagopsis*, though slightly smaller, is provided with roots, and, besides, presents other differences which are referred to in my memoir.

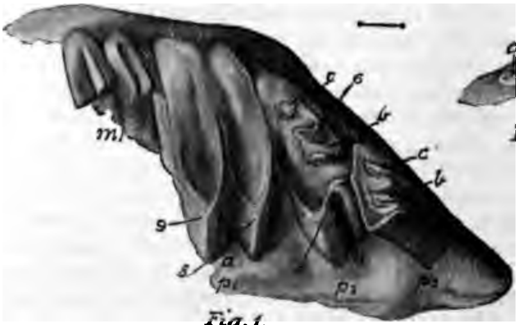

Fig. 1.

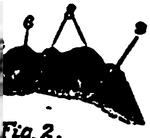

Fig. 2.

Fig. 1.—Triturating surfaces of the three upper premolars, right side, of *Lagopsis verus* (Hensel), much enlarged; from the specimen No. 42,815 in the British Museum, Geological Department.

Fig. 2.—The median premolar, p. 2, of same, from behind, much enlarged.

a, internal enamel folding; *b*, enamel crescent; *c*, enamel ring; 6, cusp, separating *b* and *c*; 8, antero-internal cusp; 9, postero-internal cusp.

We know, then, from La Grive, a deposit contemporaneous with Oeningen, apart from the small *Prolagus Oeningensis*, two larger lagomorphous Rodentia, both of approximately equal size. It is therefore *a priori* not unlikely that the larger forms from Oeningen, comprised generally under the single denomination '*Lagomys Oeningensis*,' may equally include two different animals. For this reason something more is required than mere measurements, if we wish to determine more satisfactorily these so-called '*Lagomys Oeningensis*.'

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[1] See R. Hensel in Zeitschr. deutsch. geol. Ges., viii, pl. xvi, figs. 1–3 (1856).

On inspection of the specimen No. 42,815 from Oeningen, several cheek-teeth were detected in a fragment of the cranium examined from their inner side, the bone being broken away; the lower parts of these teeth were near the crown; this latter, however, was hidden in the matrix when the specimen was placed in my hands. By carefully removing the matrix, the triturating surface of the three anterior cheek-teeth (the three premolars) could be developed, and, as a result, it became at once apparent that the fossil is a *Lagopsis*. The posterior of the three teeth (p. 1) exhibits the pattern which is shown by the homonymous premolar of *Lagomys* and by the latter's two true molars. On the outer side of this tooth is a shallow and open groove, which, as far as can be made out with a strong lens, has no enamel border. From the middle of the inner margin a lozenge-shaped narrow fold of enamel runs transversely across two-thirds of the breadth of the triturating surface, towards the outer side; the posterior enamel bordering of this fold is raised into a strong crest, running parallel with the anterior enamel bordering of the tooth, both presenting a slight anterior convexity. The enamel folding is filled with cementum in its outer narrower portion, its wider internal opening being devoid of this substance. The pattern of the median premolar, p. 2, proves that the isolated tooth from La Grive, before mentioned, has been rightly determined as p. 2. There is only a comparatively shallow internal enamel folding present in this tooth (*a*, Fig. 1); the greater part of the triturating surface being occupied by the enamel crescent (*b*, Fig. 1) before described in the tooth from La Grive. Outside from the crescent appears a small enamel ring (*c*, Fig. 1) filled with cementum, doubtless the vanishing homologue of the outer enamel crescent *c* of *Titanomys* and *Prolagus*, as elsewhere described and figured. In the La Grive specimen there is a mere vestige of some such element in the same place, the latter tooth being presumably more worn than in the Oeningen specimen. In the p. 2 of *Lagomys* the outer enamel bordering of crescent *b* is raised into a strong triangular cusp, turning its convexity inwards; in the fossil the inner border of the crescent is raised in the same manner.

The anterior premolar (p. 3) of the Oeningen fossil is not dissimilar from the same tooth of *Prolagus Oeningensis* (Kön.). Whereas in recent *Lagomys* the triturating surface of p. 3 exhibits only one enamel folding, starting from about the middle of the anterior margin and running backwards obliquely, i.e. postero-externally, the same tooth in our *Lagopsis* shows, as in *Prolagus Oeningensis*, *two* enamel foldings, opening on the anterior margin and thence running almost straight backwards.

These differences from *Lagomys* strengthen the opinion enounced by Schlosser, that the Miocene fossil is to be considered as a separate genus (*Lagopsis*), and at the same time they present a further link in the gradual transformation of the tooth-pattern (*Titanomys—Prolagus—Lagopsis—Lagomys—Lepus*), which begins in the hindmost molar of Lagomyidae, and gradually proceeds forwards, stopping at p. 1 in *Lagopsis* and *Lagomys* and at p. 2 in *Lepus*. This is not the place to enter into the details of this interesting evolution, which is exhaustively described elsewhere.

I append the measurements of the teeth described and of some of the bones of the same specimen, No. 42,815.

	mm.
Length of the three upper premolars	5·5
Breadth of p. 1	3·5
,, p. 2 (posteriorly)	3·5
,, p. 1	2·0
Length of scapula	32·5
,, humerus	36
,, ulna	36
,, femur	47

We have, then, been able to demonstrate conclusively that *Lagopsis verus* (Hens.) is a member of the fauna of Oeningen. It is not, however, in the least certain that all the large-sized Lagomyidae of the same deposit belong to this species, nor even to the genus *Lagopsis*; for my part I am looking for the discovery of *Titanomys Fontannesi* (Dep.) amongst Oeningen fossils. If the Carlsruhe specimen still exists, and is in the same condition in which it was figured by H. v. Meyer, a careful developing would doubtless give good results and allow of an exact determination .

3. CRICETODON MINUS, Lartet.

The genus *Cricetodon* is now for the first time mentioned as a member of the fauna of Oeningen. In previous lists of the mammals from this locality, the latest of which is by Depéret,[1] the genus *Mus* is enumerated; this appears to me very doubtful, the latter genus having never been met with in contemporaneous deposits.

In the Catalogue of Fossil Mammalia of the British Museum,[2] two skeletons of Oeningen from the Breda Collection figure under the heading '*Mus* (?), sp.' In one of these, No. 42,823, of which slab and counterpart are preserved, I have laid bare a molar tooth which proves to be the anterior right lower molar of a *Cricetodon*, corresponding in its size and in the character of a unicuspidate anterior tubercle to *Cricetodon minus*, Lartet, from Sansan, La Grive-Saint-Alban, Steinheim, etc.

The specimen No. 42,822, also from Oeningen,[3] is not a '*Lagomys*,' but most probably a *Cricetodon minus*; the only molar present is so much worn that I cannot be positive on the subject.

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[1] Ch. Depéret, "Classif. et Parall. du Système Miocène": Bull. Soc. Géol. France, 3e série, xxi, p. 245 (1893).

[2] I, p. 227.

[3] *Cat. Foss. Mamm.*, i, p. 258.

EXPLANATION OF PLATE XVII.

Skeleton of the type-specimen of *Sciurus Bredai*, H. v. Mey. Two-thirds nat. size. Middle Miocene: Oeningen.

R.M., right maxilla; L.M., left maxilla; R.S., right scapula; L.S., left scapula; L.H., left humerus; R.R., right radius; R.U., right ulna; L.R., left radius; L.U., left ulna; R.C., right calcaneus; R.Fi., right fibula; R.T., right tibia; L.F., left femur; L.Fi., left fibula; L.T., left tibia; C., left calcaneus; I, II, III, IV, first to fourth left metatarsals.

NOTICES OF MEMOIRS.

PRELIMINARY NOTICE OF THE ETCHEMINIAN FAUNA OF NEWFOUNDLAND. By G. F. MATTHEW. [Bull. Nat. Hist. Society of N. Brunswick; St. John, N.B., June, 1899.]

THIS paper describes in outline the species obtained from the Etcheminian rocks (below the Cambrian) in Newfoundland.

The former is interesting as showing a departure from the groupings of genera found in the Cambrian. Trilobites are said to be absent or rare; there is a great preponderance of Hyolithidæ, which are present in several different types (*Heyolithes, Orthotheca, Urotheca*, n.gen.). The other classes of animals present are all small, or even minute, except Capulidæ among the Gasteropods. The classes recognized are Brachiopoda, Gasteropoda, Lamellibranchiata, Annelida, and Crustacea. The genera are *Kutorgina, Obolella, Scenella, Randomia* (n.gen.), *Parmophorella* (?), *Platyceras, Modiolopsis, Urotheca, Helenia, Hyalithellus* (?), *Coleoides, Orthotheca, Heyolithes*, and *Aptychopsis*.

Three plates of figures accompany the article, which is supplementary to a description of the stratigraphy, etc., of the terrane in which the fossils are found, and which description appeared in the Annals of the New York Academy of Sciences, vol. xii, No. 2, pp. 41, 56.

REVIEWS.

LIFE AND LETTERS OF SIR JOSEPH PRESTWICH, M.A., D.C.L., F.R.S., F.G.S., FORMERLY PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF OXFORD. Written and Edited by his Wife. 8vo; pp. xvi and 444, with 24 illustrations. (Edinburgh and London: William Blackwood & Sons, 1899.) [1]

THIS book forms a most expressive and touching memorial from the pen of Lady Prestwich to her husband, and is embellished, as such a memorial should be, with portraits of himself in middle life and in his later years; of the ancient home of his family, "Hulme," near Manchester; of his new home, "Darent Hulme," Shoreham, Kent, where he happily spent so many of his later years;

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[1] For a life of Professor Joseph Prestwich see also GEOL. MAG., Dec. III, Vol. X (1893), p. 241 (with a portrait).

together with a series of portraits of his old friends and contemporaries: we should have welcomed also a portrait of that devoted partner, who for twenty-four years shared his scientific labours at Oxford and at Shoreham, and who aided Sir Joseph Prestwich so materially in bringing out his great work on geology,—the niece of his lamented friend Dr. Hugh Falconer.

To those who, like the present writer, knew Sir Joseph Prestwich well, this volume serves to recall not only many events of personal interest now almost forgotten, but also much of the contemporary geological history of the past half-century, in the midst of which Prestwich occupied so prominent a place, and took such an active part in helping to build up our science, contributing personally so largely to its records.

We make no apology for quoting at considerable length from the admirable summary of the scientific work of Sir Joseph Prestwich, given at the end of the present volume, by Sir Archibald Geikie, D.C.L., F.R.S., whose facile pen always affords pleasure to the reader. (See pp. 402–421.)

"The scientific career of Joseph Prestwich was marked by the long period over which it extended and by the wide range of subjects within the domain of Geology which it embraced. For more than sixty years, with indefatigable industry, he continued to contribute original observations and reflections to the science to which he had dedicated his life. His writings cover almost the whole field of geology. He discussed the various agencies, epigene and hypogene, which are now giving rise to geological changes on the earth. He studied the various geological formations from the Old Red Sandstone to the most recent gravels, but specially devoted himself to the Older Tertiary and Quaternary series. He gave much thought to the practical applications of geology, and led the way in pointing out the intimate relation between water-supply and geological structure. And lastly, he gave the world the benefit of his ripe experience and long reflection in the text-book in which he took a philosophical survey of the whole realm of geological investigation."[1]

"To gain a general idea of the nature, extent, and value of his scientific work, it will be convenient to subdivide his writings according to the several branches of geology which they illustrate. For this purpose we may first consider his contributions to our knowledge of the causes that produce geological changes, and the effects to which they give rise.

"From an early part of his scientific studies Prestwich paid close attention to the influence of running water on the face of the land. His interest in this subject was greatly quickened by his observations in connection with the high-level and low-level gravels of the river-valleys in the south-east of England and the north-west of France. From these deposits he drew the important conclusion that the valleys have been mainly eroded by the rivers which still flow in them. Though this explanation of river-valleys was strongly insisted upon by Hutton and Playfair, and had been demonstrated for Central France by Desmarest and afterwards by Scrope and Lyell, it had never attained wide acceptance among geologists. When it was adopted and enforced by Prestwich on a basis of well-ascertained fact, it came almost with the freshness of a new discovery. He quickly saw its significance in regard to the slow sculpture of the face of the land, and the great antiquity which it proved for the older and higher terraces of gravel. In his memoir read before the Royal Society in 1862, he dwelt on the evidence that could be adduced of powerful and long-continued erosion in the valleys by the streams that still flow in them; and he continued to bring forward additional proofs in support of his views, until geologists everywhere admitted the validity of his reasoning. There remained, indeed, differences of opinion as to the intensity of the operations by which the denudation had been effected. The followers of Lyell would not admit that the observed facts demanded the existence of larger rivers and more powerful floods than might be witnessed at the present time, while Prestwich was always prepared to find that the geological agents had worked on a grander scale in former times than they do now. But the fundamental fact, that the valleys of the south-east of England and the north-west of France had been carved out by the action of the rivers that drain them, was now accepted without further demur."

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[1] This work is entitled, "Geology: Chemical, Physical, and Stratigraphical." By Joseph Prestwich. In two vols. (vol. i, Chemical and Physical, pp. xxiv and 477, with 218 illustrations, Oxford, 1886; vol. ii, Stratigraphical and Physical, pp. xxviii and 606, with 256 illustrations, Oxford, 1888). Royal 8vo. Clarendon Press, Oxford.

"To Prestwich, therefore, must be assigned a not inconsiderable share in promoting the advance made during the last thirty years in the investigation of the history of terrestrial topography. He continued to interest himself in the subject up to the end of his life. Some of his last contributions to science dealt with the carving out of the river-valleys around his home at Shoreham and in the neighbouring district of the Weald." (p. 404.)

"It is interesting to note that Prestwich began his geological career by studying in minute and patient detail the coalfield of Coalbrookdale, and that he was thereafter led to explore the Old Red Sandstone of the Moray Firth. This early work was so eclipsed by the brilliance of his later researches among much younger formations, that a later generation of his contemporaries hardly realized the rare excellence and originality of his first great essay. The elaborate memoir on Coalbrookdale, presented to the Geological Society when its author was only a young man of twenty, is certainly a remarkable performance. Those to whom it was first addressed can hardly have failed to recognize in its author one of the future leaders of English geology. Selecting an area of about one hundred square miles, he carefully mapped its geology on a scale of one inch to a mile. The map was no mere sketch, but an elaborate survey, wherein the outcrops of the several seams of coal were traced, and the positions and effects of all the principal dislocations were represented. The structure of the ground was further displayed in a series of horizontal and vertical sections, while additional details were given in an excellent descriptive memoir, combining a complete account of the stratigraphy and palæontology of the district. The list of fossils, together with plates of new species, form an important feature in this publication. Not only were the organic remains of the several formations discriminated, but even the characteristic forms of successive horizons were distinguished, and the bearing of the palæontological evidence on the geological conditions of deposit were luminously discussed. This Coalbrookdale monograph must be regarded as one of the classics of English geology, making a notable advance in the progress of stratigraphy, and serving as a model for subsequent investigation of the geological structure of our coalfields. It appeared before the then recently organized Geological Survey had mapped any of those parts of the country, and it is remarkable how closely the mapping of the Survey in subsequent years followed the lines which he had laid down."

"But, unquestionably, the most important of Sir Joseph's original contributions to science are to be found in the series of papers which he wrote on the older Tertiary formations of the South-East of England, and on the younger deposits containing the earliest traces of man. This brilliant work was begun, carried on, and completed during the scanty intervals of leisure which he could snatch from a busy mercantile life. Properly to understand its scope and value we must go back to the earlier decades of this century, and take note of the vague and confused ideas then entertained by geologists as to the arrangement and stratigraphical value of the series of deposits that overlie the Chalk. The term London Clay had been applied by William Smith to those deposits from the argillaceous character of their chief member. Subsequently various geologists noticed the occurrence of a group of sandy and clayey strata between the main mass of the London Clay and the top of the Chalk. These were grouped together as Plastic Clay and Sand, but their true stratigraphical value and palæontological interest were hardly recognized. In the year 1846 Prestwich published the first of a long series of papers in which he gradually worked out the true relations of the several members of the series, and brought them into relation with their equivalents in France and Belgium. The story of this evolution of clear order out of the confusion that had preceded Prestwich's researches has been well told by Mr. Whitaker, who has followed so worthily in the footsteps of the pioneer whose labours he chronicles.[1] Beginning among the cliff sections of the Isle of Wight, Prestwich traversed every part of the Hampshire and London Basins, recording his observations on copies of the Ordnance Maps and in voluminous notebooks. From year to year he communicated his results to the Geological Society, each paper throwing new light on the history of the geological formations, until in 1854 his great essay on the Woolwich and Reading Series added the coping-stone to the edifice he had so patiently reared. He showed that between the top of the Chalk and the base of the London Clay a group of strata, which he had called the 'Lower

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[1] "The Geology of London": Mem. Geol. Surv., vol. i (1889), p. 88.

London Tertiaries,' was capable of a threefold arrangement into—1st, the basement-bed of the London Clay; 2nd, the Woolwich and Reading Series; and 3rd, the Thanet Sands. Tracing out the range and general physical features of the middle group, he brought forward numerous sections showing the local variations of the sediments from Hampshire to the east of Kent. He gave ample lists of the fossil contents of the strata, and discussed them in their bearings on the geographical conditions under which the deposits were accumulated. For the first time the succession of geological events recorded in the oldest Eocene strata of England was clearly stated."

"After reducing to order the older Tertiary series of England, Prestwich conferred a still further service on geology by bringing the English formations into line with those of France and Belgium. In a series of elaborate papers communicated to the Geological Society he established the correlation of these deposits, both lithologically and palæontologically, and in so doing became the acknowledged leader in the Tertiary geology of Western Europe." (p. 410.)

"To one of his investigations in later Tertiary geology reference may here be made as an instance of his sagacity of observation. He had long been acquainted with certain ferruginous sands scattered over the North Downs from Folkestone to Dorking. He recognized these materials to be different from the red flint drift or loam, on the one hand, and from the outliers of older Tertiary sands and pebble-beds on the other. In 1854 some highly ferruginous parts of these deposits yielded a number of casts of shells which were regarded by some palæontologists as indicating the base of the London Clay. Prestwich, however, assigned them to a much more recent period. He shared the opinion of Searles Wood, who regarded them as probably of the age of the Lower Crag. More recent observations by Mr. Clement Reid, of the Geological Survey, and the discovery of other and better preserved fossils, have left no doubt that Prestwich was entirely justified in looking upon these remnants of a once extensive deposit as Pliocene."

"Outside the rank of geologists Prestwich was probably best known for his connection with the establishment of the antiquity of man, and for his share in bringing home to the English public the enormous importance of geological knowledge in dealing with water-supply and other questions of every-day occurrence."

When in the Spring of 1859, at the suggestion of Dr. Hugh Falconer, he undertook to investigate the alleged proofs of the occurrence of flint implements, together with the remains of extinct mammalia in some of the old valley-gravels of the north of France, he entered on the inquiry with no very sanguine hope of finding that there was any good ground for the contention of M. Boucher de Perthes, who some ten years before had proclaimed his belief in the remote antiquity of the human race. But the evidence proved so strong as entirely to satisfy him that the French observer, who had met with but scant support or sympathy, was nevertheless right in his main conclusion. It was important to establish the fundamental fact that man was a contemporary of the long extinct mammals whose bones were found lying beside his flint weapons in beds of undisturbed gravel, and further to show that the deposit of this gravel, though referable to a comparatively late geological period, must be older than the present configuration of the ground. Prestwich lost no time in communicating the results of his examination of the Abbeville region to the Royal Society. He cautiously abstained from pronouncing on the antiquity of man, contenting himself with pointing out that though there could be no doubt that man was contemporary with certain extinct forms of elephant, rhinoceros, deer, and other animals, no evidence had yet been obtained to show the chronological value of the interval that had elapsed since the deposit of the gravels containing the worked flints. He himself was at first inclined, not so much to throw the human period indefinitely backward, as to bring down the period of the extinct mammalia nearer to our own day, and to account for their disappearance and for the modification of the superficial topography by some sudden or rapid geological change, which, though transient, was powerful enough to leave its memorial on the surface of the land. As his investigations proceeded he felt the weight of evidence continually augmenting in favour of the long lapse of time required for the excavation of the valleys and for the production of the vast changes in the configuration of the land since the accumulation of the implement-bearing gravels. In his next great memoir, published in 1864, he admitted that 'we must greatly extend our present chronology with respect to the first existence of man; but that we should count by hundreds and thousands of years is, I am convinced, in the present state of the inquiry, unsafe and premature!' In this valuable essay, the whole evidence of the valley-gravels and of the gradual erosion of the valleys is marshalled with great skill, and discussed with characteristic clearness and caution. In later essays he admitted that man was living in Glacial or Post-Glacial times, which came down approximately to within 10,000 or 12,000 years of our own day.

"Thus it is to Prestwich, more than to any other geologist, that we owe the establishment of the fact that man coexisted with a number of now long extinct mammals, and that his advent on the earth must be relegated to a far higher antiquity than that which had been previously accepted. While he was engaged in the researches that led to these results he at the same time greatly enlarged our knowledge of the later phases of the Ice Age, particularly in the river-valleys of the south of England and north-west of France. The term 'Drift' has been vaguely applied to a multifarious series of superficial deposits, differing widely from each other in origin and in age. Prestwich strenuously contended for the local origin of the gravels in which flint implements and mammalian remains occur together. He showed that these accumulations unquestionably belonged to the river-systems within which they are found, that they were fluviatile in origin, and were deposited by the streams *which* still flow in the same valleys. He maintained, however, that the rivers were formerly vastly larger than they now are; that, in virtue of their size, width, and transporting power, they were able to carry downward and spread out over their flood-plains the widely distributed sheets of course shingle now remaining; while from time to time they rose in floods of extraordinary magnitude that deposited the fine silt, containing land-shells, which is now to be seen covering all the different gravel-beds. Considerable differences of opinion still exist, however, regarding some of these deductions. Other observers, as remarked above, have been unable to perceive any satisfactory evidence that the rivers were generally more swollen than they are at present, though at exceptional periods of melting snow they may have surpassed in volume any floods chronicled in their valleys during historic times. But Prestwich detected the traces of another transporting agent than that of mere unaided river-water. In the presence of large unworn blocks among the ancient gravels, together with much sharp angular detritus, he recognized the operation of river-ice. Thus, all over the south-east of England, where the climate is now so mild, he traced indications that in old times the rivers flowing on the platform of the higher gravels were frozen over; that ice forming along their margins or over their bottoms lifted and carried along the shingle and boulders lying there, and that when these Arctic conditions prevailed, man had already appeared, fishing in the rivers, or tracking the mammoth, the bison, and various extinct forms of deer through the surrounding forests and prairies."

"Among Prestwich's contributions to the history of the latest geological changes that have affected the South of England and North of France, his numerous papers on the so-called Raised Beaches of this region deserve recognition." (p. 415.)

"One of the most useful services rendered by Sir Joseph Prestwich to the cause of his own science was the active share he took in the practical applications of geology. His labours in this department were manifested in two different directions. In the first place, he, more than other geologists of his day, insisted on the necessity of a knowledge of geological structure in dealing with the question of water-supply. From his early communication to the Institute of British Architects down to his pamphlet on the Oxford Water-Supply, an interval of thirty-five years elapsed, during which he came to be regarded as the leading authority on this subject in England, and his co-operation doubtless added much to the value of the Report of the Royal Commission on Water-Supply issued in 1869. It is to be regretted that the maps prepared by him for this Report were never published. In the second place, his early devotion to the coalfield of Coalbrookdale gave him a knowledge of our Carboniferous system, and an interest in its development, which he turned to good use in later years, when he acted as a member of the Royal Commission on Coal. Not the least valuable part of that important and voluminous work was supplied by him in his papers on the quantity of unwrought coal in the coalfields of Somerset, and on the probability of finding coal under the newer formations of the

South of England. In the last-named paper he gave a resumé of all that had been ascertained up to the year 1866 regarding the possible extension of the Coal-measures, and gave good grounds for supporting the conclusions of Godwin-Austen, and for believing in 'the high probability of the existence of basins [of coal] under the Secondary and Tertiary formations of the South of England.' This opinion, and the reasoning on which it was based, have recently acquired fresh interest and value from the successful borings for coal in Kent." (p. 418.)

"It may not be inappropriate to refer here to the influence which Prestwich exerted on his scientific contemporaries. The writer of these lines, who knew him well for many years, may perhaps be permitted to bear his testimony to the remarkable and perennial charm of his personality. While we revered him as one of the last of the old heroic race of geologists; while we honoured him for the endless enthusiasm and perseverance with which, often in the midst of many hindrances, he devoted every leisure moment to the cause of geology; while we admired him for his infinite patience, the scrupulous caution, and the laborious exhaustiveness of his researches, we loved him for the gentle, child-like simplicity of his heart, his unaffected modesty, and his genuine goodness. His bright sunny temperament always found out what was best in those with whom he came in contact. His unfailing sympathy delighted to find expression in active helpfulness. The smile that lighted up his handsome features seemed to reveal at one glance the tenderness, kindliness, and truthfulness of his nature. One felt after an interview with him cheered and brightened by contact with one whose serene old age seemed to place him so far above the littleness and troubles of life. While his writings will perpetuate his scientific achievements, it should be placed on record that it was not these achievements alone which gave Sir Joseph Prestwich his pre-eminence among his contemporaries, but that he owed this position in large measure to the integrity and charm of his character." (p. 421.)

Sir Joseph Prestwich's career most aptly illustrates the proverb—"The child 's the father of the man." Beginning from his earliest youth with remarkable habits of application to study, with great industry and self-denial, coupled with an intense love of science and a keen desire to be a geologist, he yet submitted, from a strong sense of duty and obedience, to work at his father's city business from 18, and so went on until he was 60 years of age. During those forty-two years of uncongenial mercantile cares, Prestwich squeezed into their leisure hours a lifetime of scientific work, such as few men could have accomplished had they devoted all their existence to it, unhindered by any business calls or anxieties whatever.

The following are a few of Sir Joseph Prestwich's leisure-hour achievements:—138 published scientific books, memoirs, and papers. Elected an F.G.S. in 1833, elected and served on the Council of the Geological Society 1846-68, one of the *founders* of the Palæontographical Society 1847, elected an F.R.S.

in 1853, served as one of the Secretaries of the Geological Society 1855, became Treasurer of the Geological Society 1856–68, appointed a Royal Commissioner on Water Supply 1865, appointed a Royal Commissioner on Coal Supply 1866, elected President of the Geological Society 1870–72, Vice-President of the Royal Society 1883. In 1849, when only 37 years of age, Prestwich received the "Wollaston Gold Medal." On 23rd June, 1874, when 62 years of age, having already accomplished a lifetime of work, he was elected Professor of Geology in the University of Oxford, as successor to Professor John Phillips, F.R.S., a Chair which he held for fifteen years, retiring in 1887, at the age of 75 years! In 1874 the Telford Gold Medal and premium were awarded to Professor Prestwich for his paper on "The Geological Conditions affecting the Construction of a Channel Tunnel." He was made an Honorary D.C.L. (Oxon) in 1888, and received knighthood in 1895 (æt. 84). Truly it may be said of Sir Joseph Prestwich in the words of Chaucer—

"He was a verray perfight gentil knight." H. W.

CORRESPONDENCE.

NOTE ON *AMMONITES EUOMPHALUS*, SHARPE.

Sir,—The *locality* given by Sharpe for his type of this Ammonite is quite wrong. Dr. Rowe and myself have just returned from a survey of the Dorset coast, and Mr. Crick has shown me the type. The matrix of Sharpe's specimen is identical with that of the specimen from Humble Point collected by us, and closely approximates to the matrix of the specimen collected by the Geological Survey. There is no matrix anything like it in Man o' War Cove, nor is there anything like it in any of the Dorset coast sections. It undoubtedly came from the Whitland's section in Devonshire.

This is an excellent example of the confusion caused by accepting any previous records, when attempting to do zonal work or make tables of occurrences. The fossils should be personally collected by those who are responsible for the stratigraphy; error is then reduced to a minimum. C. Davies Sherborn.

OBITUARY.

SIR WILLIAM HENRY FLOWER,

K.C.B., LL.D., D.C.L., D.Sc., F.R.C.S., Ph.D., F.R.S., F.L.S., F.G.S., Pres.Z.S.,
KNIGHT OF THE PRUSSIAN ORDER "POUR LE MÉRITE," ETC., ETC., ETC.

Born November 30, 1831. Died July 1, 1899.

Few men have had the satisfaction to see so large a share of their hopes and ambitions in life realized as Sir William Flower.

Born in the historic town of Stratford-on-Avon, where his father's family had already resided for many years, he had the good fortune to be the second son, and was consequently permitted, from his youth up, to pursue that innate love of natural history which springs eternal *in the schoolboy* breast, but seldom lasts till manhood. In young Flower's case it was to last a lifetime, for it was fostered through his being early brought in contact with that veteran naturalist and geologist, the Rev. P. B. Brodie, M.A., F.G.S., who was the first person, as Flower himself informed the writer, to inspire him with a taste for collecting fossils and other natural-history objects, and to stimulate his powers of observation in the field as a zoologist.

After his schooldays were over, he matriculated at the University of London in 1849, with honours in Zoology, and in the same year he entered the Medical Classes at University College and became a pupil at the Middlesex Hospital. Here he gained the gold medal in Dr. Sharpey's class in Physiology, and the silver medal in Zoology, and passed the first M.B. of the London University in 1851. In 1854 he became a member of the Royal College of Surgeons; he shortly afterwards joined the 63rd Regiment, and embarked for Constantinople, war with Russia having just then been declared. The sufferings of the British Army in the Crimea are now a matter of history, and young Flower, who passed the first winter with his regiment there, experienced all the severity of the climate, officers and men being alike without tents and even necessary warm clothing, suffering from frostbite and exposure for many weeks every night in the open air. Mr. Flower, who was never of a very robust constitution, at length broke down and was invalided home; soon after receiving, at the hands of the Queen, the war-medal with clasps for the Alma, Inkermann, Balaclava, and Sebastopol.

Shortly after his recovery, he joined the staff of the Middlesex Hospital as Demonstrator in Anatomy, and resigned his position in the Army in order to settle and take a practice in London. In 1857 he passed the examination for the Fellowship of the Royal College of Surgeons, and next year was elected Assistant-Surgeon to the Middlesex Hospital, holding also the office of Curator of the Museum and Lecturer on Comparative Anatomy in the same institution.

In 1858 he married Georgiana Rosetta, youngest daughter of Admiral W. H. Smyth, F.R.S., the well-known Astronomer and Hydrographer.

In 1861 the important office of Conservator of the Museum of the Royal College of Surgeons of England, commonly called the "Hunterian Museum," became vacant by the death of Professor Quekett. The collections under the Conservator's charge were most extensive, and very varied in their nature, embracing Surgery, Pathology, Anatomy, Physiology, Zoology, and Palæontology, and some knowledge of these diverse subjects was required by the occupant of the office. The appointment was, however, congenial to Mr. Flower's tastes, and for it he gladly relinquished the practice of his profession and his connection with the Middlesex Hospital; he henceforth devoted himself wholly to scientific pursuits. The care of the Museum and its complete reorganization and gradual augmentation constituted for many years his principal employment, every department having unfortunately fallen into arrears, as regards cataloguing and arrangement, at the time he took charge of it. The Hunterian Professorship of Comparative Anatomy and Physiology (which for twenty-five years had been held in conjunction with the conservatorship of the Museum by Professor Owen) had been separated from it some time previously, and was then held by Professor Huxley, who, however, was compelled by the pressure of other engagements to relinquish it in 1869, when the two offices were again united by the appointment of Mr. Flower to the Professorship, the duties of which consist in the delivery of a short course of lectures, on different subjects each year, illustrated by the preparations in the Museum.

Professor Flower was elected a Fellow of the Royal Society in 1864, and served several times on the Council. In 1879, on the death of the Marquis of Tweeddale, President of the Zoological Society, he was elected to succeed him in that office, and he held the Presidency up to the time of his death, a period of twenty years; he had previously served for years on the Council and as one of the Vice-Presidents. He was elected a Vice-President of the Anthropological Institute of Great Britain and Ireland in 1879, and President in 1883.

In connection with the British Association for the Advancement of Science, he has held the offices of Vice-President of Section D (Biology), Norwich, 1868; President of the same section at Dublin, 1878; President of the Section of Anthropology at York, 1881; of Biology at Oxford, 1894; and President of the British Association at Newcastle-on-Tyne, 1889. He was also President of the Section of Anatomy at the International Medical Congress in 1881. He was several times Examiner for the Natural Science Tripos in the University of Cambridge, and delivered lectures at the Royal Institution, Albemarle Street.

In 1884 Professor Flower was appointed Director of the Natural History Departments of the British Museum, Cromwell Road, as successor to Professor Sir Richard Owen, retired; which post he held till October, 1898, when failing health compelled him to relinquish active work, and he was succeeded by Professor E. Ray Lankester, D.C.L., F.R.S., the present Director of that Institution.

The Royal Society awarded him one of its Royal Medals in November, 1882, for his contributions to the Morphology and Classification of the Mammalia, and to Anthropology. He received the honorary degrees of LL.D. of the University of Edinburgh and of Dublin in 1878, and D.C.L. of Durham in 1889. He was made a C.B. in 1887 and a K.C.B. in 1892.

Among Sir William Flower's contributions to Anatomy and Zoology may be mentioned "A Supplement to the Catalogue of the Pathological Series in the Museum of the College of Surgeons," 1863; "A Catalogue of the Series of Human Osteology," 1879; "Introduction to the Osteology of the Mammalia." 1870; "Fashion in Deformity, as illustrated by the Customs of Barbarous and Civilized Races," 1881; "Observations upon the Posterior Lobes of the Cerebrum of the Quadrumana," 1862; "On the Commissures of the Cerebral Hemispheres of the Marsupialia, as compared with those of the Placental Mammals," 1865; "On the Development and

Succession of the Teeth in the Marsupialia," 1867, in which the remarkable peculiarities of the milk-dentition in that group of animals were first clearly demonstrated; "The Affinities and Probable Habits of the Extinct Australian Marsupial *Thylacoleo*," 1868; "On a newly-discovered Extinct Mammal from Patagonia," 1873; seven memoirs on the anatomy of the Cetacea, or whale-like animals, in the Trans. Zool. Soc.; and in the Proceedings, papers on the "Classification of the Carnivora," on the Anatomy of the Musk-Deer, the Elephant-Seal, the Common Fin-Whale, and many other animals; "Observations on the Osteology of the Natives of the Andaman Islands," 1879, of the Fijians, 1880, and the Mallicollese in 1881; "The Palæontological Evidences of the Gradual Modification of Animal Forms," 1873; "The Extinct Animals of North America," 1876; and "Native Races of the Pacific," 1878.

His separate works comprise "Introduction to the Osteology of Mammalia," of which three editions have been published; "Introduction to the Study of Mammalia, Living and Extinct" (in conjunction with R. Lydekker, F.R.S.), 1891; "The Horse, a Study in Natural History," 1892; and "Essays on Museums and other subjects connected with Natural History," 1898. The long series of articles on Mammalia in the "Encyclopædia Britannica" were also written by Sir William Flower.

Apart from Flower's position as a leading authority on the Mammalia, more especially the Cetacea, he will always be recognised as *facile princeps* amongst Museum Curators: his chief object in life since his appointment to the post of Conservator of the Museum of the Royal College of Surgeons, and until his retirement from the Directorship of the Natural History Museum, Cromwell Road, having been to arrange, display, and label specimens, so as to give to the inquiring student, or the intelligent visitor the greatest instruction and enjoyment from a survey of the cases and galleries under his charge. He certainly inspired all those who were capable of being influenced by his example with a spirit of emulation and a desire to make the very best of their own section of the Museum. The remarkable series of illustrations of variation, of coloration, of mimicry, and of the anatomy of the vertebrata, which adorn the cases of the Central Hall, are in themselves a monument to his genius.

Although unable, through failing health and weakened bodily powers, to achieve the completion of the rearrangement of the Zoological Galleries (a task undertaken far too late for realization), he was nevertheless enabled to show in a temporary annexe at the west end of the Museum the most instructive series of models of Cetacea, displaying on one side the actual skeleton and on the other the restored external life-like characters of these huge monsters of the deep, which, belonging to the highest group of vertebrate animals, yet surpass in bulk the hugest of the old Dinosaurs or any other extinct reptiles that trod the earth, or tenanted the waters in Jurassic or Cretaceous times.

Truly it may be said of Flower in connection with the arrangement of the collections in the Natural History Museum—

"Si monumentum quæris, circumspice." H. W.

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No. IX.—SEPTEMBER, 1899.

ORIGINAL ARTICLES.

I.—Note on the Discovery of *Miolania* and of *Glossotherium* (*Neomylodon*) in Patagonia.

By Francesco P. Moreno, F.R.G.S., Corr.M.Z.S.Lond.,
Director of the La Plata Museum.

SINCE 1877, when I discovered the Tertiary Mammalian beds of Santa Cruz, in Patagonia, I have been looking for proofs of the ancient connection between the new uplifted lands of the southern part of the American continent and the other lands of the Southern Hemisphere—Africa and Australia. During my subsequent travels in the interior of the Argentine Republic, including Patagonia, my interest in that connection has been increasing, and I have discovered additional evidence, which showed me the former greater extension to the east, in comparatively modern times, of the actual existing lands. The splendid results of the researches made by the La Plata Museum in Patagonia have revealed a great number of lower forms of vertebrates, including numerous marsupialia, some of which seem to me closely related to the mammals of the Pleistocene fauna of Australia, and among them *Pyrotherium* with *Diprotodon*. I think that my suggestion has an indubitable confirmation in the discovery made by the expeditions which I sent in 1897 and in the first months of this year, under the direction of Mr. Santiago Roth, expeditions that have had astonishing results.

In beds containing remains of mammals and dinosaurians, Mr. Roth discovered in 1897 a caudal sheath-ring, very similar to those of the *Glyptodon*, but which I at once recognized as pertaining to a form like the chelonian of the Pleistocene of Queensland, described by Owen. I brought this fossil with me to London for comparison with the remains of *Miolania* preserved in the British Museum (Natural History). The resemblance was great, but the fact of a Tertiary chelonian from Patagonia being analogous to the Pleistocene genus from Queensland and Lord Howe Island was so astonishing, that some doubt was permitted; but, having previously ordered a new examination of the fossiliferous bed where the remains were found, I have now the certainty of the extremely close relation between the Australian and Patagonian chelonian. I have received several photographs of a skull discovered by Mr. Roth, which photographs, when compared with the Australian specimens in the British Museum (Natural History), give no place for doubt upon this matter. I think that it is sufficient for the present to give two cuts representing the two forms of *Miolania*. I expect in a few days the original specimen from Patagonia, together with various bones and additional remains of the caudal sheath, with some of the carapace. These will be the subject of a special description by Mr. Arthur Smith Woodward, who has so kindly commenced studies on the fossil reptiles in the La Plata Museum.

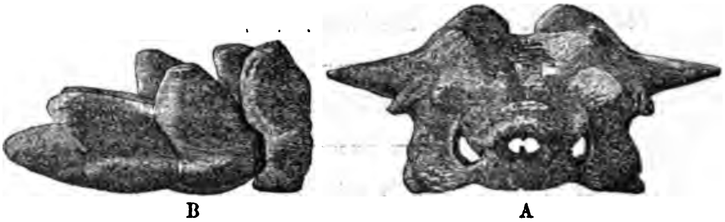

Fig. 1.—Front view of skull (A) and side view of tail-sheath (B) of *Miolania Oweni* (greatly reduced), from Pleistocene Deposits, Queensland, Australia. [Originally described as *Megalania prisca* (Owen, 1880).]

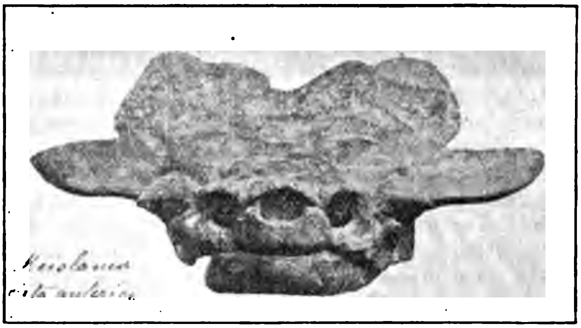

Fig. 2.—Reproduction of photograph of the front view of skull (with the lower jaw) of *Miolania*, obtained in 1899 from Patagonia by Mr. Santiago Roth, of the La Plata Museum, Argentina. (Greatly reduced in size.)

I have also brought with me to London a piece of a skin discovered in a cave near Last Hope Inlet (lat. S. 51° 30′), which I have referred to a species of the extinct *Mylodon* (see, "On a Portion of Mammalian Skin, named *Neomylodon listai*, from a Cavern near Consuelo Cove, Last Hope Inlet, Patagonia." by Dr. F. P. Moreno, C.M.Z.S.; with a description of the specimen by A. Smith Woodward, F.Z.S.); while Mr. Ameghino has announced that another piece of the same skin pertains to a mammal still living, of small size, which he has called *Neomylodon*. When I took this piece at Last Hope Inlet in

November, 1898, I was convinced that it was part of the skin of a ***Mylodon*** or a form very similar to it, and that the discovery was of great importance to me, as I think that the Pampean muds, where the extinct Edentata are found, are of very modern age, an opinion contrary to that held by another observer, Mr. Ameghino, who refers the Pampean fauna to the Tertiary age. I have already maintained that the extinction of the greater part of the Pampean fauna took place after the presence of man in a relatively advanced culture, called Neolithic culture. Having, then, great interest in the continuation of the investigations in the cave, I ordered, before coming to London, more extensive researches, and these have been made with very successful results.

Dr. Otto Nordenskjöld had previously obtained in 1896 a piece of the same skin, which, it is known, was discovered by a party of Argentine surveyors during the preliminary studies for the boundary between Argentina and Chili in the Andean Cordillera, and, recognizing also the importance of it, Dr. Erland Nordenskjöld went last year to the same spot to look for some more remains. The excavations which he made gave him, so far as I know, some bones, pieces of jaws, teeth, and claws of the same animal, but he did not obtain more remains of the skin.[1] My assistant, Mr. Hauthal, arrived later at the cave, when Dr. Erland Nordenskjöld had terminated his researches, and commenced further exploration. He obtained, not only skulls, jaws, teeth, bones, and claws, but also a nearly complete skin of the animal, which shows that it is a *Glossotherium*, together with bones of ***Macrauchenia***, ***Equus***, and ***Auchenia***, also a great quantity of dung, hay cut by man, ashes, and some bones worked by man. I am not yet sure if the bones of man discovered by Mr. Hauthal were found in the same cave or in one of those in its neighbourhood; but the presence in the *Glossotherium* deposit of bones worked by man is a proof that man and other mammals, whose remains have been discovered in the cave, were contemporary. I suggest that the skin has been preserved by man for bedding. In the caves inhabited by ancient man in Patagonia I have seen cut hay, and probably this also was used for beds.

I expect to receive in a few days all these specimens at the same time as those of the *Miolania*, together with reports on the discoveries, and I think they will arrive in time for me to exhibit these remains at the meeting of the British Association at Dover.

The discovery made by Mr. Roth of some advanced Mammalia in the beds that contain dinosaurians, and Mr. Hauthal's discovery of remains of extinct vertebrates and other mammals in the caves of Southern Patagonia, associated with *Macrauchenia*, horse, *Auchenia*, and man, are proofs of the very recent changes in the physical geography of Patagonia, and afford most interesting problems, which can only be solved by a systematic examination of the Argentine country by experienced geologists. In the course of my paper read before the Royal Geographical Society, I proposed that this Society, the Royal Society, and the British Museum, with other scientific institutions, should proceed to carry out these necessary investigations. These problems are not extraneous to the explorations which may be carried out by an Antarctic expedition, and I think the new discoveries which I now communicate to the GEOLOGICAL MAGAZINE may urge on the dispatch of such expeditions as I propose. If these expeditions be made, how many changes may be produced in actual and general ideas on the age of the South American fossiliferous strata, on the disappearance of the lost southern lands, and on the affinities of extinct faunas so distant in time and space as those of South America and Australia.

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[1] E. Nordenskjöld, "Neue Untersuchungen über *Neomylodon listai*": Zool. Anzeiger, vol. xxii (1899), *pp. 335, 336*.

II.—CONTRIBUTIONS TO FOSSIL CRUSTACEA.

By Professor T. RUPERT JONES, F.R.S., F.G.S., and HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XV.)

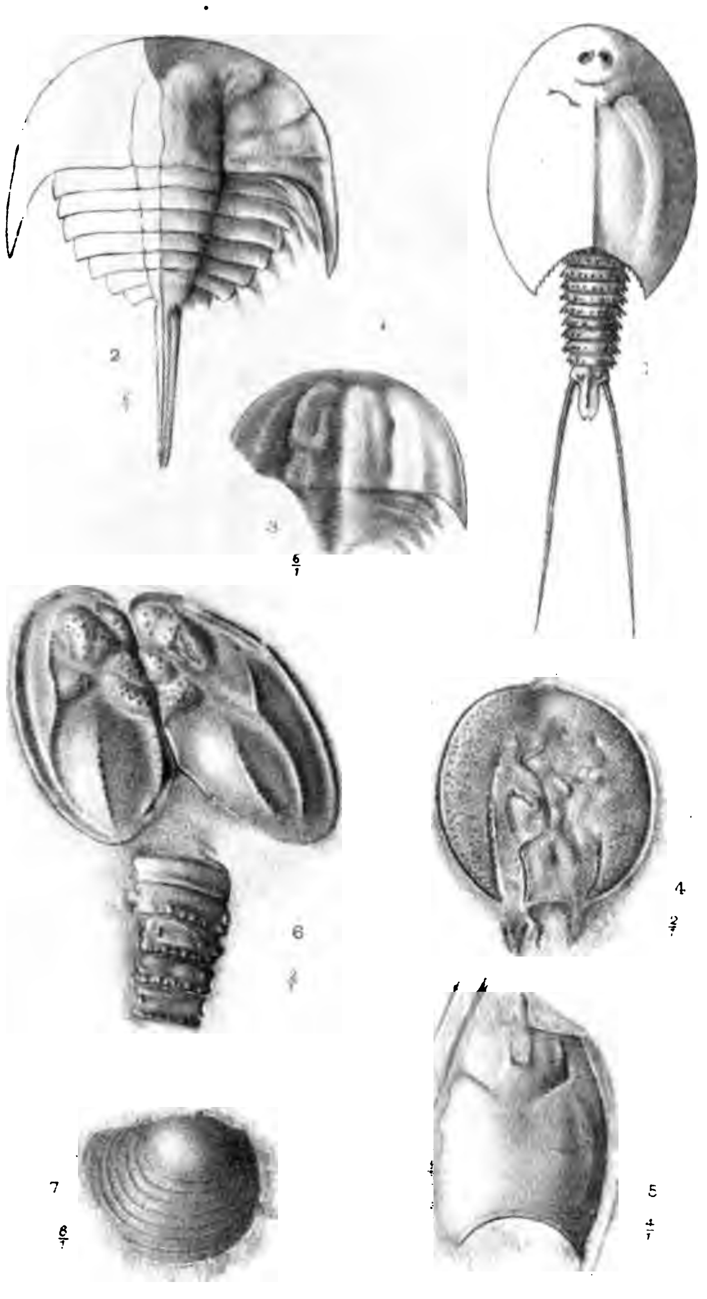
THE following notes are devoted to a small series of Crustacea, not directly related to one another, but which have been awaiting a favourable moment for description.

1. BELLINURUS GRANDÆVUS, Jones & Woodw. (Pl. XV, Figs. 2 and 3; × 6 diam.)

Through the kindness of our friend Dr. Henry M. Ami, M.A., F.G.S., Assistant-Palæontologist to the Geological Survey of Canada, and with the permission of the Director, Dr. G. M. Dawson, C.M.G., F.R.S., we received, a year ago, two tiny specimens of Palæozoic Limuloid Crustaceans, referable to the genus *Bellinurus* of König. Dr. Ami writes:—"The precise locality of these protolimuloid Crustaceans is the 6th cutting east of Riversdale Station on the Intercolonial Railway of Canada, in the county of Colchester, Nova Scotia. There are besides this Crustacean (which you are at liberty to describe if you wish) a number of plant- and animal-remains associated in the same beds, viz.: *Asterophyllites acicularis*; *Sphenopteris*, sp.; *Cyclopteris* (*Aneimites*), sp.; Ostracoda; *Anthracomya obtenta*, etc., etc. A species of *Leaia*, closely related to *Leaia tricarinata*, also occurs here, and fern-pinnules allied to *Neuropteris*, besides *Calamites*, *Cordaites*, etc. The shales from which these Crustaceans were obtained are overlain conformably by sandstones and red shales of great thickness, and these in turn are unconformably capped by Lower Carboniferous Marine Limestones. Thus, in descending order the strata are:—

1. Lower Carboniferous Marine Limestones.
   (Unconformity.)
2. Red rocks of Union and Riversdale Series.
3. Black, grey, and glossy shales of Riversdale and vicinity.
   (Unconformity.)"

1. Turning to the specimens themselves, the label states "the *first* specimen found by Mr. Ami" (which is represented on Pl. XV, *Fig. 3*, enlarged six diam.) is said to be from the "3rd cutting



G.M. Woodward ad nat. lith.

West, Newman

1. Recent, 2-7. Fossil Crustacea.

STANFORD LIBRARIES

east of Colnary River (30, vi, 1897)," and shows a nearly entire head-shield and a portion of five thoracic segments of a small Limuloid Crustacean, probably near to *Bellinurus reginæ*, Baily, from the Irish Coal-measures, and measuring in its present imperfect state 5 mm. in breadth and 4 mm. in length. The cephalic buckler is twice as broad as it is long; the angles of the shield are moderately produced, and the ocular and median ridges of the shield are very distinctly marked, and also the position of the compound eyes; the thoracic segments are distinct, and sharply pointed at their free extremities. The margin of the head-shield is slightly thickened and raised, and the front margin somewhat depressed. The telson or tail-spine is not preserved. Each specimen is *intaglio*.

2. The second specimen obtained ("6, vii, 1897") is labelled from the "*Asterophyllites* or 6th cutting east of Riversdale, Colchester Co., Nova Scotia." Although only one side of the specimen and the telson are preserved, it happens to take in rather more than one-half, so that by tracing and reversing the outline one obtains a very correct idea of the form of the entire animal (Pl. XV, Fig. 2). The specimen is larger than No. 1, measuring 9 mm. in length and 7 mm. in greatest breadth when restored. The artist did not detect the ocular line in this specimen, but it is really present as a minute depressed line outside the glabella, having a deeper spot where the compound eye was situated. Three radiating lines seen on the right side of the head-shield are probably traces indicating the presence of some of the six pairs of maxillipeds or jaw-feet seen in the modern King-crab (*Limulus*). The cheek-spines of the head-shield are well developed, and extend backwards to the 4th thoracic segment. Five well-defined thoracic segments can be distinctly observed, and two (or three?) shorter abdominal ones in front of the telson. The lateral margins or pleuræ of these thoracico-abdominal segments appear to be distinctly truncated, unless, as is just possible, their pointed extremities may have been detached and have adhered to the counterpart impression of the specimen which has not been preserved. The median axis of these segments rapidly diminishes in breadth from the head towards the telson, as is seen to be the case in *Bellinurus reginæ*. The telson or tail-spine is robust, and rather more than one-third of the entire length of the animal.

As stated elsewhere—see Pal. Soc. Mon., "Brit. Foss. Crustacea: The Merostomata," Part V (Xiphosura), 1878, p. 236—we believe that the five segments composing the thorax in *Bellinurus* were free and moveable, as in the larval stages of the young of the living *Limulus polyphemus* and *L. Moluccanus*, and that such was also the case in *Neolimulus falcatus*, H. Woodw., from the Upper Silurian, Lesmahagow, Lanarkshire, the earliest Limuloid Crustacean that we know.

Although *Bellinurus* is a very ancient type of *Limulus*, it has not at present been found in rocks of earlier age than the Coal-measures, nor can we assert that the black, grey, and glossy shales of Riversdale, Colchester Co., Nova Scotia, in which these specimens occur, are older than Carboniferous.

Leaia Leidyi, T. R. Jones, which occurs with *Bellinurus* in these Riversdale black shales, occurs in the Lower Carboniferous of Pennsylvania, but in rocks "regarded by some geologists as the uppermost part of the Devonian or Old Red Sandstone."[1] *Leaia* also occurs in the Upper Coal-measures of Lancashire and the Lower Carboniferous of Fifeshire (Jones, op. cit.).

In his "Acadian Geology" (3rd edition, 1878), Sir William Dawson gives an interesting account of the geology of Colchester Co., Nova Scotia, and figures *Leaia Leidyi* (misspelt '*Leidii*') from the Lower Carboniferous Coal Formation (see p. 256, fig. 78*e*). At p. 258 he also gives a section at Walton which would seem to justify the inclusion of the Red Rocks of Union and Riversdale in the Lower Carboniferous Series, thus uniting these disturbed beds in one group. But this suggestion is made with the utmost diffidence, in the absence of a knowledge of the district.

As the two specimens of *Bellinurus* (Pl. XV, Figs. 2 and 3) are both imperfect, and better materials may at any time be forthcoming, it seems prudent to refrain from suggesting more than one trivial name. This Crustacean may therefore be known as *Bellinurus grandævus*, Jones & Woodw., Lower Carboniferous Series, Riversdale, Colchester Co., Nova Scotia.

2. HIBBERTIA ORBICULARIS, gen. et sp. nov. (Pl. XV, Fig. 4.)

This small Crustacean shield, together with other specimens, was presented to the British Museum, many years ago, by our late friend Dr. John Millar, F.G.S., of Bethnal House, Bethnal Green. The specimen is imbedded in a finely laminated, micaceous, non-calcareous shale (bluish-grey in section), and bears the label "Coal M., Burdiehouse." It was at first believed to be one of Dr. Hibbert's types from Burdiehouse, but nothing like this fossil was found to have been figured or mentioned in Dr. Hibbert's memoir[2] on the strata and fossils of Burdiehouse; therefore, its occurrence there, as shown by its old label, is of great interest. It was reserved for description with other Phyllopods to form part of a monograph in course of publication by the Palæontographical Society; but upon further examination it was found to differ so markedly from the other members of this division that it was held over for some time for further consideration and comparison. It has now become necessary to give it a name, and place it approximately among its congeners.

Specific Characters.—A nearly circular shield, 14 mm. broad by 15 mm. long, having an opening behind, bounded by two acute incurved angular spines which form the backward extremities of the concentric shield or buckler-like test. The periphery of the concentric part of the test is turned up sharply as a thin rim in the fossil, leaving a uniform narrow groove behind it, from which the field of the buckler rises with a gentle swelling over and along the

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[1] "Fossil Estheriæ": Pal. Soc. Mon., 1862, p. 117, pl. v, figs. 11, 12.

[2] See Dr. S. Hibbert's memoir, Trans. Roy. Soc. Edinburgh, vol. xiii (1836), *p. 280, plates.*

crescentic area, except where the edge falls in for a little space just on the centre of the front border; where the buckler becomes slightly depressed and the narrow groove along the margin is interrupted or perhaps injured there is an obscure impression of what may have been a jointed antennary organ in front. The surface of the two lateral areas of the buckler have a finely granulated ornamentation, which is most marked just within the peripheral rim of the carapace, and is limited by two thin parallel granulated ridges, each starting from the incurved posterior angles of the shield, the longest being 7 mm. and the shortest only 4 mm. in length; the intervening space of 5 mm. in breadth, forming the centre of the carapace, is devoid of the granulated ornament seen on the other parts of the shield, and has only a small spine-like impression 3 mm. long, which extends for three-quarters of the entire length of the shield as a curved irregular incised line. There are some other markings, too obscure for interpretation; also a slight posterior projection on the central line, as if possibly representing a part of a lost series of caudal segments (?).

The presence of the two corresponding angles, and the narrow posterior opening between them, suggests affinities with *Dithyrocaris* (cf. *D. Scouleri* as represented by McCoy, with its two raised lateral ridges), but in most of the members of this group the lateral portions of the shield are less circular in outline, and in many the surface ornamentation is composed of linear or reticulate, and only occasionally of granulate markings. Compared with the shield of *Apus* or *Lepidurus*,[1] the general outline is much alike, but the granulated mesolateral ridges continued forward from each of the posterior angles in *Hibbertia* are not present in *Apus*, whereas the median ridge so conspicuous in both *Apus* and *Dithyrocaris* is apparently quite absent in *Hibbertia*, or is not preserved in the fossil. Contrasted with the anterior (cephalic) buckler in *Limulus*, the shield of *Hibbertia* is seen to be nearly circular, whilst that of *Limulus* is semicircular; the posterior angles of the shield of *Hibbertia* are contracted together and directed somewhat inwards at their extremities, whilst in *Limulus* they are wide apart and directed rather outwards. The mesolateral (ocular) ridges are present both in *Hibbertia* and *Limulus*, but in *Limulus* they form a curved line, not a straight ridge as in *Hibbertia*.

The granulation on the lateral areas of the shield and on the ridges is also strange to *Apus*, and more closely resembles that seen in some species of the Carboniferous genus *Cyclus* (cf. *Cyclus Johnsoni*, H. Woodw.,[2] and *C. testudo*, Peach, the former from the Coal-measures of Coseley, near Dudley, the latter from the Carboniferous shales—so rich in Crustacea, Arachnida, etc.—of Eskdale on the Scottish borders).[3]

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[1] See Plate XV, Fig. 1, copied from Dr. A. S. Packard's figure. (Mon. Phyllopod Crustacea of North America, 1883, pl. xvi, fig. 1.)

[2] See "Contributions to our Knowledge of the Genus *Cyclus* from the Carboniferous Formation of various British Localities," by H. Woodward: GEOL. MAG., Dec. IV, Vol. I (1894), pp. 530–9, Pl. XV.

[3] Trans. Roy. Soc. Edinburgh, vol. xxx (1883), p. 227, pl. xxviii, figs. 9–9d.

None of the earlier fossil forms of Limuloid Crustaceans hitherto figured and described (examples of two of which, Figs. 2 and 3, are given on Pl. XV with *Hibbertia*, and of which a series may be studied on pl. xxxi, figs. 1–8, Pal. Soc. Mon. Merostomata, part v, 1878) aid us in finding a suitable form for comparison with the shield of *Hibbertia*, nor do the larval stages of the recent *Limulus* greatly assist us in this direction (see op. cit., pl. xxxiii). We are therefore reduced to the conclusion that *Hibbertia* may be more conveniently placed along with and near to those forms referred to the genus *Cyclus* than with any other group. Under these circumstances we prefer to regard it as being characteristic of a distinct genus, and we name it after Dr. Hibbert, with whose discoveries in the Carboniferous strata at Burdiehouse it is most closely associated.

From the paper by H. Woodward, already referred to, we make the following extract, to show the conclusions arrived at by the writer as to the affinities of the curious little forms included in the genus *Cyclus*, to which family, under the name of *Hibbertia*, our specimen from Burdiehouse must now be added.

"The presence of antennæ and biramous swimming-legs proves undoubtedly that *Cyclus* was a Crustacean. The large size of the former and the homogeneous nature of the rest of the appendages (all biramous swimming-legs, with possibly masticatory bases), taken in connection with the large, slightly-bivalved carapace, suggest that it is an Entomostracan and probably one of the Phyllopoda, with a broad cephalic carapace like that possessed by *Apus* and by *Daphnia*; with large swimming second antennæ like the latter, and possibly with a pair of stalked eyes. *Cyclus*, however, differs from the Cladocera in being flattened dorso-ventrally, and from the lowest Crustacea in not apparently possessing any true jaw-parts—the head, with the labrum and mouth, being bent further back than in the living Entomostraca. These differences may either indicate very lowly characters or very much specialized ones. Two views suggest themselves:—

"(1) That these animals were small, free-swimming Phyllopods, with expanded cephalic shield, swimming second antennæ, and biramous limbs, the bases of which served as masticatory organs, no true jaws having yet been developed; the backward position of the mouth may have been brought about in order to allow as many appendages as possible to serve as jaws, as is seen in *Limulus*. Or, possibly, the beast could attach itself, like a living *Daphnia*, by a cement gland on the dorsal side of the head, in which case it might be an advantage to have the mouth as near the freer end as possible and close to the swimming-legs, which were, by their movements, producing the foot-currents.

"(2) The other view is that these animals were ecto-parasitic Phyllopods, although they had not lost their power of free-movement, yet had become specialized in the form of their body, which is flattened ventrally and only slightly convex above, the whole animal being expanded horizontally, unlike most other

Phyllopods. This view might account for the two large round structures seen on the ventral surface, situated one on either side of the body, and close to the anterior margin of the shell. These might possibly represent a pair of ventral suckers, such as are seen in the modern fish-lice; these structures, whatever they may be, are evidently enormously developed, and possess great muscles, which produce prominent modifications of the dorsal shield, where they are attached. The great labrum might possibly represent the suctorial tube of *Argulus*, under cover of which are concealed the reduced mandibles, etc.

"Some of the specimens show curious oblique scars on the coxæ of the legs, which may indicate the points of attachment of spines or setæ to enable the parasite to stick to its fishy host." (GEOL. MAG., 1894, pp. 534–5.)

3. ANTHRAPALÆMON GLABER, Jones & Woodw. (Pl. XV, Fig. 5.)

This small cephalothoracic shield of a Macrouran Decapod Crustacean was obligingly sent to us by our friend and correspondent, Mr. John Smith, of Monkredding, Kilwinning, who obtained it in the Coal-measure series of Kilmaurs, Ayrshire. The other specimens which accompanied this will be dealt with elsewhere. The specimen, which is 7 mm. long and 5 mm. in breadth, displays a gently rounded, almost smooth carapace, preserved on a fragment of fawn-coloured shale enclosing plant-remains. The carapace has no dorsal ridge, but there is a well-marked cervical furrow forming an open V-shaped depression across the carapace in the centre; a small but prominent rostrum is seen in front, and the cervical furrow gives rise to a gastric furrow and spine on either side, only one of which, however, that on the right side, is preserved. The sides of the carapace are slightly expanded and smoothly arched, and there is a faint trace of a serrated border on the hepatic region, terminating in a short anteriorly directed spine. The posterior border is deeply and roundly emarginated, and has a thickened, raised, and smooth rim. The surface of the test is smooth, and quite free from ornamentation. The specimen closely resembles *Anthrapalæmon Etheridgei*, figured and described by Mr. B. N. Peach, F.R.S., from Eskdale (see Trans. Roy. Soc. Edinb., 1883, vol. xxx, figs. 4 and 5), but may be specifically separated from it by its absence of ornamentation; it may bear the trivial name of *A. glaber*.

Locality.—Coal-measures: Kilmaurs, Ayrshire.

4. ECHINOCARIS WHIDBORNEI, Jones & Woodw. (Pl. XV, Fig. 6.)

The following note on *Echinocaris* has been most obligingly sent to us, together with the three specimens, by Mr. A. K. Coomára-Swámy, the discoverer of the beautiful specimen drawn on Pl. XV, Fig. 6:—

"This phyllopod was first described and figured in the GEOL. MAG., Dec. III, Vol. VI (1889), p. 385, Pl. XI, Fig. 1, by Professor Rupert Jones and Dr. H. Woodward, from a specimen found by Mr. Dufton in a quarry at Sloly, near Barnstaple, in beds of the Baggy or Marwood series, associated with *Lingula squamiformis* and other fossils. There is also a fragmentary specimen in the Porter collection, from Pilton, near Barnstaple. Mr. Dufton's specimen was redescribed and refigured by the Rev. G. F. Whidborne in the 'Monogr. Devonian Fauna of the S. of England' (Pal. Soc., vol. iii, pt. 1, 1896, p. 6, pl. i, fig. 3). In 1896 I was in the Sloly quarry with the Geologists' Association, and found a small slab bearing one good specimen [Pl. XV, Fig. 6] and a cast of another. Later, the same day, the corresponding half was found by Mrs. A. M. Davies. These specimens are referred to in the Proc. Geol. Assoc., vol. xiv, pt. 10, p. 440, and in the Brit. Assoc. Report of the Committee on Paleozoic Phyllopoda, 1897. In my specimen the valves are slightly elongated and narrowed by shearing, but are nevertheless equal in breadth to those of the first specimen. Five body-segments are visible. They bear the tubercles characteristic of *Echinocaris* on their posterior margins. The other specimen, occurring as an impression on the same slab, is smaller; three body-segments are seen in Mrs. Davies' half. Two other specimens have since been found by Miss Partridge, of Barnstaple, in the same locality."

By the kindness of Mr. A. K. Coomára-Swámy we have been allowed to study his own specimen, and also the two obtained by Miss E. M. Partridge, of Barnstaple. One of Miss Partridge's specimens (732) shows evidence of the body-segments behind the carapace; both valves are present, but rather squeezed out of shape. The other specimen (759), although the valves are less perfect behind, shows the anterior border with the granulated surface of the valves very beautifully, and what appear to be two ocular spots (or tubercles) near the anterior border. We are much indebted to Miss Partridge and also to Mr. A. K. Coomára-Swámy for the opportunity to see and examine these rare Devonian Phyllopods.

5. ESTHERIINA EXTUBERATA, sp. nov. (Pl. XV, Fig. 7.)

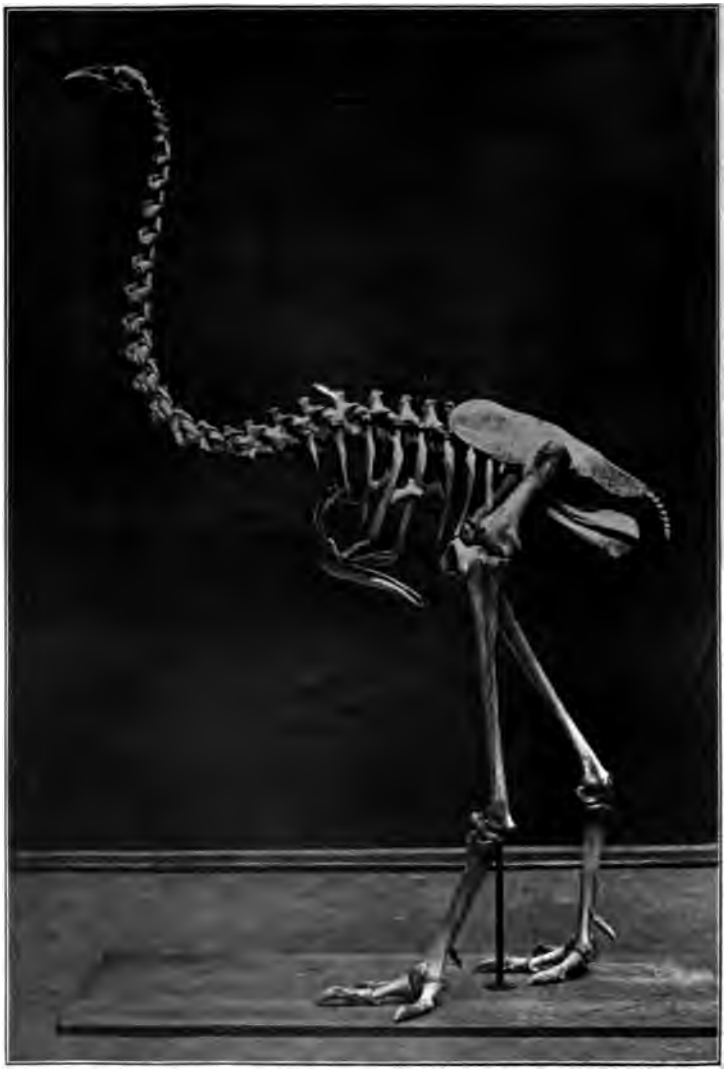
This seems to be the very tumid umbonal portion of a right-hand valve of an *Estheriina*, separate from the rest of the valve. The flat marginal portion of the valve may have been broken away, or perhaps lies hidden in the matrix.

Size.—Length 3 mm., height 2½ mm.

The valve is semicircular on the ventral and nearly straight on the dorsal border; but the swollen umbo bulges out to some extent at the anterior third of that hinge-line. It slopes gently down to a rather blunt angle in front, and with a short hollow slope to a sharp angle behind.

The umbo is large, convex, very smooth, and shiny, 1½ mm. broad, 1 mm. distant from the anterior and scarcely ½ mm. from the posterior angle. It extends downwards for 1 mm. nearly to the middle of the valve, and is succeeded by seven concentric, broad, undulatory ridges, each having a raised line, mostly ¼ mm. apart, with smooth interspaces.

The strong local convexity of the valve, succeeded by a limited *series* of coarse concentric riblets, reminds us of the similar feature



Dinornis maximus, Owen.

Specimen discovered by Mr. C. A. Ewen at Invercargill, South Island, New Zealand.

Height as mounted, 8 ft. 6 in.

in *Estheriina* (Geol. Mag., May, 1897, pp. 193, etc., Pl. VIII, Figs. 1–11); but there is wanting the flat outer extension of the valve along its free margins. It may be a separate umbonal boss, such as occurred with the Brazilian specimens, and one of them also was described as being shiny (loc. cit.).

Indeed, the specimen under notice much resembles the very distinct umbonal area of *Estheriina astartoides* (as represented in Pl. VIII, Fig. 7, Geol. Mag., 1897), with its six or seven coarse riblets and their smooth interstitial spaces; the umbo itself, however, is relatively much larger in the German specimen. The Brazilian fossil, from a cutting on the railway 83 kilometres from Bahia, was in a shale of Cretaceous age. The Stegocephalian limestone from which Baron von Reinach obtained the specimen here described is of Permian age.

This little fossil was communicated to us for description by Professor Fried. Kinkelin, of the Senckenberg Museum, Frankfurt-on-the-Maine. It was found by Baron A. von Reinach[1] in the Stegocephalen-Kalk near that city.

EXPLANATION OF PLATE XV.

Fig. 1. — ***Lepidurus glacialis*** (after Dr. A. S. Packard). (Mon. Phyllopod Crustacea, North America, 1883, pl. xvi, fig. 1.) Recent: North America.

„ 2. } ***Bellinurus grandævus***, Jones & Woodw. Lower Carboniferous Series:
„ 3. } Riversdale, Colchester Co., Nova Scotia. × 6 times nat. size.

„ 4.—***Hibbertia orbicularis***. Jones & Woodw. Coal-measures: Burdiehouse, near Edinburgh. × twice nat. size.

„ 5.—***Anthrapalæmon glaber***, Jones & Woodw. Coal-measures: Kilmaurs, Ayrshire. × 4 times nat. size.

„ 6.—***Echinocaris Whidbornei***, Jones & Woodw. Marwood Beds (Devonian): Sloly, near Barnstaple, Devon. × twice nat. size.

„ 7.—***Estheriina extuberata***, sp. nov. Permian: Frankfurt-on-the-Maine. × 8 times nat. size.

III.—Note on a nearly complete Skeleton of *Dinornis maximus*.

By Chas. W. Andrews, B.Sc., F.G.S., British Museum (Nat. Hist.).

(PLATE XVIII.)

AN exceedingly well-preserved and nearly complete skeleton of the largest species of *Dinornis*, *D. maximus*, has recently been mounted and exhibited in the Palæontological Galleries of the British Museum (Natural History). The finding of this fine specimen has been described by its fortunate discoverer, Mr. C. A. Ewen,[2] and to his paper a brief account of the remains themselves was added by Captain Hutton.[3] It appears that the bones were found on shifting sand-dunes about a mile from the sea in the neighbourhood of Invercargill (South Island). The bones had been buried under several feet of sand which had been removed by the wind, exposing a portion of the pelvis, the remainder being still buried in wet sand. The skull was found in remarkably perfect condition, and some 200 ossified tracheal rings were collected. A few days previously another skeleton had been discovered under similar circumstances, and it is probable that from time to time others may be exposed.

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[1] Baron von Reinach has communicated to us other Phyllopods from the Permian of the Wetterau and the valley of the Nahe; see Rep. Brit. Assoc. for 1893 (1894), pp. 465–6, pl. i, figs. 1–5.

[2] "On the Discovery of Moa-remains on Riverton Beach": Trans. New Zealand Institute, vol. xxviii (1895), p. 651.

[3] Tom. cit., p. 652.

Some two feet below the skeleton, Mr. Ewen came upon rotten flax-sticks and a bed of water-worn shingle, and he considers that probably these marked the position of the bed of an old watercourse down which the carcases of the birds drowned by floods were washed.

The two skeletons thus brought to light differ from one another in some important particulars. Thus, in the specimen now figured it is stated that the basi-occipital is deeper, the maxillary processes much less developed, the paroccipital processes do not extend so far back, the temporal fossæ are deeper and broader, the basisphenoidal region is longer and the premaxillæ shorter and considerably narrower than in the skull of the other specimen. Moreover, with this latter only seven tracheal rings were found, while with the present specimen there were about two hundred. Professor Hutton has made some interesting remarks (*loc. cit. supra*) as to the probable nature of these differences. He points out that they may be (1) sexual, (2) specific, (3) merely the result of individual variation, and for several reasons comes to the conclusion that they are sexual, the skeleton of the male being that now figured, the other of the female.

The most important reasons for this conclusion are, firstly, that in the case of the last-mentioned specimen a great number of fragments of egg-shell were found among the bones, in such a position as to render it highly probable that the egg was inside the bird at the time of its death; and secondly, the tracheal rings in the same individual were incompletely ossified. The skull is remarkably well preserved. It shows the flattening and deflection of the broad blunt premaxillary region, the marked inclination forward of the occipital plane, and the other characters enumerated by Professor T. J. Parker as characteristic of the genus *Dinornis*.[1] The tracheal rings are elongate-oval in outline, the long axis being 32 mm., the short 14 mm.; and since almost all are of exactly the same shape, there can be no doubt that they have not been distorted by pressure or otherwise. The width of the band of bone of which they are composed varies from about 5 mm. opposite the ends of the long axis to 4 mm. opposite the short.

Some of the measurements[2] of the skull are given below.

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[1] "On the Cranial Osteology, Classification, and Phylogeny of the Dinornithidæ": Trans. Zool. Soc., vol. xiii (1895), pp. 417, 418.

[2] Measurements taken according to the rules laid down by Professor T. J. Parker *in the paper above referred to.*

	mm.
Length of skull	227
Length of *basis cranii*	47
Width at paroccipital processes	93
„ temporal fossæ	69
„ squamosal prominences	107
„ postorbital processes	133
Distance between temporal ridges	42
Greatest length of premaxilla	144
Width of body of premaxilla	72
Width of lower end of quadrate	40
Length of mandibular ramus	209
Greatest depth of mandibular ramus	25
Length of symphysis	31

In the skeleton as mounted there are only twenty true cervical vertebræ, and of these the fifth and seventh have been restored in plaster. The atlas is abnormal, there being no bony bridges over the vertebral arteries. There is a large median hæmapophysis on the last cervical and on the four succeeding vertebræ, and a trace of it on the fifth. The neural spine of the last cervical, like those of the vertebræ behind it, is not bifid. There are two or three cervico-dorsals and three or four free dorsals; of the cervico-dorsals the second has been restored. The presence of only twenty cervicals instead of twenty-one may be accounted for by the probable loss of one of the anterior cervicals.

The sternum of this specimen was unfortunately broken into many fragments, but has been, as far as possible, mended and restored in plaster. Although many pieces were missing, its general outline is probably as nearly as possible correct, and it is interesting to note that it differs in several respects from the sternum referred to this species by Owen ("Extinct Birds of New Zealand," pp. 415–16, pl. xcviii), being relatively narrower, and having less divergent postero-lateral processes and an unbifurcated xiphisternum; the last-mentioned feature, however, is not quite certain, this region being very imperfect. There are facets for the articulation of two pairs of ribs. Both coraco-scapulæ are preserved.

The pelvis, which was in a very good state of preservation, presents no important peculiarity.

The bones of the hind limbs are perfect with the exception of the hind toes, of which only one claw is preserved, and the inner toe of the right foot.

Some measurements of this specimen are given below:—

	ft.	in.
Total height as mounted	8	6
Height to top of pelvis	5	7
Length of femur	1	3¾
Length of tibio-tarsus	2	7½
Length of tarso-metatarsus	1	7
Width of distal end of tarso-metatarsus ...	0	6¼
Length of middle toe	0	11

IV.—The Silurian and Ordovician Rocks exposed on the Shore near Balbriggan, County Dublin.

By Charles Irving Gardiner, M.A., F.G.S., Cheltenham College.

BALBRIGGAN is a village in County Dublin, some nineteen miles north of Dublin, and along the coast in its neighbourhood Ordovician and Silurian[1] rocks are exposed for a distance of about five miles. These are described in the Irish Survey Memoirs,[2] but from a recent investigation of the locality it seems desirable to give a fresh account of its geology.

The rocks exposed seven miles to the south, at Portraine, have been recently examined and found to be, in the main, of Middle or Upper Bala age,[3] while some unfossiliferous grits were doubtfully assigned to the Silurian period, owing to their similarity to the grits occurring at Balbriggan amongst which it was announced that several species of *Monograptus* had been found.

The river Delvin runs into the sea about two miles north of Balbriggan, and it is on the south side of its estuary that, coming from the north, one first meets with Palæozoic rocks, after the long strip of coast occupied by Quaternary deposits south of Drogheda. The beds exposed near the Delvin are green grit, and slates dipping S.S.W., and are the lowest beds observed along the coast. Near Lowther Lodge black slates are seen, and a good deal of intrusive diabase and two small dykes of kersantite are noticeable. Sections from this latter rock show well-formed bleached micas with much decomposed felspars. Quartz, calcite, and chlorite have been met with as secondary minerals, while a good deal of apatite occurs.

Opposite the Cardy Rocks, olive-brown slates occur, much veined with diabase intrusions, and in these slates *Leptæna sericea* was found, while the Survey Memoir gives the following fossils as coming from these beds:—[4]

Favosites fibrosa.
Calymene brevicapitata.
Cybele verrucosa.
Leptæna sericea.
Orthis Actoniæ.
Orthis calligramma.
Orthis porcata.
Strophomena alternata.
Strophomena deltoidea.

These fossils mark the beds as being of Bala age.

The beds now curve round so as to dip S.E., and after a small fault a few bands of brown slates are seen and a garnetiferous ash, and then for nearly two miles the shore is occupied by a series of igneous rocks. These are, in the main, andesites, sections of the rocks showing much decomposed plagioclase felspars in a groundmass chiefly made up of secondary chlorite and calcite, with numerous small felspar microlites. Amygdales are fairly common, and are generally composed of calcite and chlorite.

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[1] The term Silurian is used in this paper to include rocks from the Llandovery Beds to the Ludlow Beds.

[2] Memoir to accompany Sheet 92 (1871), Geol. Surv. Ireland.

[3] Q.J.G.S., vol. iii (1897).

[4] Memoir to accompany Sheet 92, p. 21, Geol. Surv. Ireland (1871).

Amongst these lavas several bands of ashes were found, one of them fairly coarse, but the bulk of them fine in texture. Two intrusions of a somewhat coarse diabase were also noted.

The dip of the ash beds was, wherever visible, to the S.S.E., but its angle could not be determined with accuracy. The coarse ash can be seen in a hand-specimen to include fragments of extremely amygdaloidal lava, and the microscope shows that in the finer rocks these originally pumiceous fragments were also entombed.[1]

Just south of Balbriggan the cliffs are made of Drift, but at the next headland beyond the village igneous rocks are again found; these are still andesitic, and are covered by fine grey-green ashes, with, on one horizon, a layer of large included fragments of a fine purple ash.

About 340 feet of brown slates are then seen dipping at about

,, *triangulatus* (Harkn.). *Petalograptus palmeus* (Barr.).
,, *Hisingeri* (Carr).

From this fossil evidence it seems probable that these slates are at the top of the *M. gregarius* zone of the Middle Birkhill.

The next graptolitic black slates are about 500 feet above the lowest one noted above, and has yielded obscure species of *Monograptus*, but 10 feet higher comes a band with *M. spinigerus* (Nich.) and *M. priodon*? (Bronn), while 70 feet above this band is one with *M. spinigerus* (Nich.), *M. Hisingeri* (Carr), and *M. Galæensis* (Lapw.), and 80 feet higher still a band yielding *M. Hisingeri*? (Carr). These fossils seem to show that the bands which they characterize are in the *M. spinigerus* zone of the Upper Birkhills.

A slight change in the direction of the dip is now seen, the beds being still fine grits with layers of black slates at intervals, and their dip being 35° S.S.E. The next graptolitic layer, 85 feet above the last one mentioned, contains a species which appears to be *M. Riccartonensis* (Lapw.), and the same fossil occurs in two bands a little higher up in the series.

About 1,200 feet of rock occur above the highest of these three bands, chiefly made of grey grits, with here and there black slates, and then the beds begin to curve up in the opposite direction and

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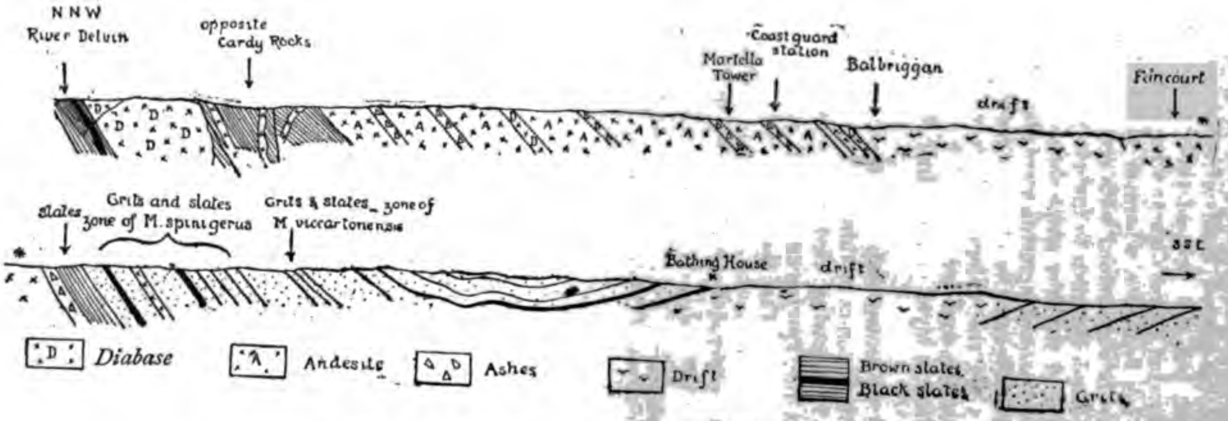
[1] See Geikie's "Ancient Volcanoes of Great Britain," vol. i, p. 244.

[2] All the graptolites mentioned in this paper have been examined for me by Miss Elles, of Newnham College, Cambridge, and my best thanks are due to her for her extreme kindness in so doing.



Section along the Coast near Balbriggan, Co. Dublin, Ireland.

(Length of Section, 4 miles: Scale, 3 inches to the mile.)

dip to the N.N.W. At the axis of this syncline the beds roll slightly and small dislocations have occurred, and then for about half a mile to the south-east one sees a repetition of the succession one has already passed over while coming from Balbriggan. Unfortunately, just where the graptolitic slates should be exposed, the Palæozoic rocks are obscured from view by a thick capping of drift, and when next Primary rocks are seen they are the grey grits occurring below the graptolitic slates, and from this point the shore-line follows the strike of the beds all the way to the village of Skerries. Near this place are three islands showing gritty beds dipping south-east at 30° and higher, while ash beds are seen as well, corresponding no doubt to the ash beds between the igneous series and the grits to the south of Balbriggan.

Thus the geological evidence of this strip of coast shows that after the Middle Bala period, when the Cardy Rock slates were laid down, there came a great outpouring of andesitic lavas with occasional scatterings of ashes on the igneous rocks. Subsequently the lavas were covered by ashes, on which grits and slates were deposited. These last rocks are shown by their fossils to be of Silurian age, and the equivalents of the zones of *Monograptus gregarius* (Lapw.) and *M. spinigerus* (Nich.) in the Birkhill shales; while higher still come graptolitic bands which, if their fossil evidence be correctly determined, must represent a much higher horizon and are the equivalents of the Wenlock beds.

Unfortunately, the specimens are very poorly preserved, and Miss Elles states that they "resemble very closely *M. Riccartonensis.*" This species, she advises me, is usually found in a definite horizon above the *Cyrtograptus Murchisoni* zone (which is at the base of the Wenlock Beds), or else in the highest part of that zone. Consequently, if this specific determination be correct, we have between the highest fossiliferous band of the *M. spinigerus* zone of the Llandoveries 85 feet of rock before we come to the first fossiliferous band of the Wenlocks.

In County Down somewhat similar graptolitic shales have been described by Swanston.[1] There the zone of *M. spinigerus* is covered by the Portaferry Beds, with *M. Riccartonensis.*

The thickness of the beds in the Balbriggan section is not easy to determine, but the following approximate numbers have been arrived at:—

Wenlock-Llandovery Beds...	2,300 feet shown.
Igneous series.	
Bala sedimentaries	1,700 feet shown.

What the date of the diabase and other intrusions was there is no evidence to enable one to find out.

Further south at Portraine the igneous series of andesitic lavas was overlain by calcareous rocks of Middle Bala age, so that from the two areas we may conclude that there was a great outflow of andesitic rocks in this part of Ireland in Middle Bala times. There is nothing in this area approaching the coarse tuffs and breccias of Lambay Island, and the coarse porphyry so well seen on that island and occurring also at Portraine is not to be seen near Balbriggan.

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[1] Report of the Belfast Field Club, 1876–7.

It is obvious that as we go away from Lambay Island we are getting away from the great centre of eruption, and though the explosive outbursts did carry ashes as far as Balbriggan, yet it was not very frequently that they did so. It is also worthy of remark that no trace of calcareous rocks are to be seen in the Balbriggan area. The conditions requisite for the formation of such rocks obtained during Middle Bala times both at Lambay and at Portraine, but near Balbriggan shales and shales alone are the result of sedimentary deposition during that period.

V.—On some Pliocene and Post-Pliocene Shells from Egypt.

By R. Bullen Newton, F.G.S.

(PLATES XIX AND XX.)

THE following notes have been drawn up from a small series of shells belonging to the late Tertiary and Post-Tertiary formations of Egypt, which form part of a collection of fossils sent home for determination by Captain Lyons, R.E., Director-General of the Geological Survey of Egypt.

The principal literature on this subject has been furnished by Leith Adams,[1] S. P. Woodward,[2] Oscar Fraas,[3] Sir William Dawson,[4] and Professor Edward Hull.[5] To the two former we are indebted for some of our earliest knowledge respecting the occurrence of fluviatile shells of Post-Tertiary age at high levels in the Nile Valley; and to the remainder for valuable information on the beaches and sea-beds found in the neighbourhood of the Gizeh Pyramid and the Mokattam Hills, formerly regarded by Fraas as of Miocene age, but which more modern observers have recognized as Pliocene.

Connected with the Quaternary history of Egypt, although not of conchological interest, reference should be made to the two important reports by Professor Judd[6] on the delta deposits of the Nile as examined by a series of borings carried out under the auspices of the Royal Society to ascertain at what depth the solid rock might be reached, a result unfortunately not achieved, for after piercing the alluvial beds to a depth of 345 feet from the surface and 319 feet below sea-level at Zagazig, operations were suspended without meeting with the basal formation. The first of these reports deals with the mineral and chemical nature of the deposits, whilst the other includes some information upon the Foraminifera.

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[1] "Notes on the Geology of a Portion of the Nile Valley north of the Second Cataract in Nubia, taken chiefly with the view of inducing further Search for Fluviatile Shells at High Levels": Quart. Journ. Geol. Soc., vol. xx (1864), pp. 6–18.

[2] "Note on the Fresh-water Shells collected in Nubia by Dr. Leith Adams": Quart. Journ. Geol. Soc., vol. xx (1864), p. 19.

[3] "Aus dem Orient," 1867, pt. i, pp. 161–7.

[4] "Notes on the Geology of the Nile Valley (Raised Sea-margins; Mokattam Terraces from the Nile)": Geol. Mag., 1884, pp. 289–292.

[5] "Memoir on the Geology and Geography of Arabia Petræa, Palestine, etc.," 1886, pp. 70–72.

[6] First Report, "On a Series of Specimens of the Deposits of the Nile Delta obtained by the recent Boring Operations": Proc. Roy. Soc. London, 1886, vol. xxxix, p. 213. Second Report, "On Specimens of Deposits of the Nile Delta obtained by Boring Operations undertaken by the Royal Society": ibid., 1897, vol. lxi, p. 32.

MOLLUSCA: GASTEROPODA.

Genus PLANORBIS, Geoffroy.

Traité Coq. Fluv. Terr. Paris, 1767, pp. 12, 81.

TYPE.—*Helix cornea*, Linnæus.

PLANORBIS PFEIFFERI, F. Krauss. (Pl. XIX, Figs. 6–8.)

Planorbis Pfeifferi, Krauss: Die Südafrikanischen Mollusken, 1848, p. 83, pl. v, fig. 7.

DESCRIPTION.—*P. testa cornea, nitida, diaphana, oblique striata,*

☞ **Plates XIX and XX, illustrating this Article, will appear in the October Number.**

separated by its more convolute spiral system, a smaller umbilical area, and less lenticular shape.

HORIZON.—Post-Pliocene (Lacustrine or Fluviatile Deposits).

DISTRIBUTION.—Natal: Umgani Valley (Krauss). Egypt: near Farshut, Nile Valley. Coll. Geol. Surv. Egypt (No. 1,040, Box No. 52*c*).

Genus MELANIA, Lamarck.

Mém. Soc. Hist. Nat. Paris, 1799, p. 75.

TYPE.—*Helix amarula*, Linnæus.

MELANIA TUBERCULATA, Müller. (Pl. XIX, Figs. 9–11.)

Nerita tuberculata, O. F. Müller: Verm. Terrest. Fluv. Testaceorum, vol. ii (1774), No. 378, p. 191.

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[1] Malakozoologische Blätter, vol. xvi (1869), p. 39; Novitates Conchologicæ, vol. iv (1870), p. 25, pl. cxiv, figs. 13–16.

[2] Malakozoologische Blätter, vol. xvii (1870), p. 35; Novitates Conchologicæ, vol. iv (1870), p. 23, pl. cxiv, figs. 6–9.

Melania tuberculata, Brot, "Die Melaniaceen (Melaniidæ)": Syst. Conchyl.-Cabinet, 1874, p. 247, pl. xxvi, fig. 11. Edward Hull: Mem. Geol. Palestine, etc., 1886, p. 80.

Description.—*Nerita testa subulata, cinerea, transversim striata; anfractibus nodulosis, strigisque sanguineis.* (Müller.)

Remarks.—The Egyptian specimens referred to this shell exhibit the usual characters of the species. Numerous spiral lines ornament the moderately convex whorls, these being crossed by oblique rows of tubercles, which become more or less obsolete as the last whorl is reached. Hull records this species as occurring in a semi-fossil state in some marl terraces 20 feet high at Ain Abu Werideh, in the Jordan-Arabah country, which is about 1,400 feet above the level of the Dead Sea. For a further synonymy of the species Dr. Brot's work should be consulted.

Dimensions.—Length, 31 mm.; diameter, 11 mm.

Horizon.—Post-Pliocene (Lacustrine or Fluviatile Deposits).

Distribution.—Tripoli, Algeria, Egypt, Madagascar, India, Ceylon, Java, and Australia (Recent specimens). Palestine: Ain Abu Werideh. Egypt: near Farshut, Nile Valley. Coll. Geol. Surv. Egypt (No. 1,041, Box No. 53*c*).

MOLLUSCA: LAMELLIBRANCHIATA.

Genus ALECTRYONIA, Fischer (Waldheim).

Museum-Demidoff, vol. iii (1807), p. 269.

Type.—*Mytilus cristagalli*, Linnæus (*A. rara*, Fischer).

Alectryonia cucullata, Born. (Pl. XIX, Figs. 1–5.)

Ostrea cucullata, Born: Musæi Cæsarei Vindobonensis, 1780, p. 114, pl. vi, figs. 11, 12.

Ostrea Forskali and *Ostrea cornucopiæ*, Chemnitz: Conchylien-Cabinet, vol. viii (1785), p. 30, pl. lxxii, figs. 671*a*–*c*; p. 41, pl. lxxiv, figs. 679*a*–*b*.

Ostrea Forskali, Brocchi: Conch. Fossile Subapennina, vol. ii (1814), p. 566.

Ostrea undata, Lamarck: Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 217. Basterot: Mém. Soc. Hist. Paris, vol. ii (1825), pt. 1, p. 1. Serres: Géognosie Terr. Tertiaires France, 1829, p. 136, pl. vi, figs. 4, 5.

Alectryonia cucullata, Chenu: Manuel Conchyliologie, 1862, p. 197.

Ostrea cucullata, and vars. *comitatensis*, *occitania*, *Ruscinensis*, Fontannes, "Moll. Pliocène Rhône et Roussillon": Invert. Bassin Tert. Sud-est France, vol. ii (1879), p. 228, pl. xvii, figs. 7–9; pl. xviii, figs. 5–7.

Ostrea pseudo-cucullata, Fuchs: Palæontographica, vol. xxx (1883), p. 36 (54), pl. xix (xiv), figs. 10–13.

Alectryonia (*Ostrea*) *cucullata*, Viguier, "Etude Pliocène Montpellier": Bull. Soc. géol. France, sér. iii, vol. xvii (1889), p. 413, pl. x, figs. 2–5.

Ostrea cucullata, Ficheur: Desc. Géol. Kabylie du Djurjura, 1890, p. 382.

Ostrea cucullata, var. *Byzacena*, P. Thomas, "Desc. quel. Foss. Tunisie": Explor. Scient. Tunisie, 1893, p. 21, pl. xiii, figs. 6–11.

Ostreola Forskali, and vars. *undulatior*, *perrostrata*, *subcucullata*, *persacellus*, F. Sacco: Moll. Tert. Piemonte, pt. xxiii (1897), p. 16, pl. v, figs. 1–3 and 6–12.

Description. — Shell oblong in shape, with plicated valves. The lower or convex valve deeply excavated, of variable width, with sometimes nearly parallel sides, and furnished with an elongate, straight, or curved ligamental rostrum, with its summit usually directed backwards, and bearing a moderately deep triangular fossula; interior of more or less rectangular form, and ornamented externally with a few slightly-elevated radial costæ crossed by a regular series of growth-lines. The upper valve is depressed, somewhat lamellose, oblong, frequently narrow at the ligamental area, exhibiting on the outer surface some obscure longitudinal plications; the muscular-scar impressions are superficial and scarcely perceptible.

Remarks.—The Egyptian specimens referred to this species are exactly comparable, not only with the living representative as it occurs off the shores of the Red Sea, but also with some Italian Pliocene forms that have been examined in the British Museum (Natural History)—No. 80,943—and which are labelled as *O. undata*, the equivalents of Born's *O. cucullata*. Much more elongate ligamental rostra appear to distinguish specimens from the Pliocenes of Tunis, Montpellier, and the Rhône Basin, the Tunis specimens being also more numerously plicated than others. It is undoubtedly a most variable mollusc, and authors are pretty generally agreed that it should embrace *O. Forskali* and *O. cornucopiæ* of Chemnitz, as well as Lamarck's *O. undata* as figured by Serres. Certain distinctions have been pointed out in this species which are said to be more or less constant at the various localities where it has been found, thus giving rise to the introduction of a number of varietal names by such writers as Thomas, Fontannes, Viguier, and Sacco; but although these details are carefully worked out, they do not appear to be adapted for general application. Under *O. Forskali*, Chemnitz alludes as far back as 1785 to the discovery of this mollusc in a fossil state in Egypt by Professor Forskal. From late Tertiary deposits near Cairo, Fuchs has described and figured an oyster called *O. pseudo-cucullata*, which cannot possibly be separated from Born's species; it corresponds exactly with an example of similar dimensions from the Pliocene (Astian) of Italy. In confirmation of this opinion, it is satisfactory to know that Dr. Schweinfurth came to the same conclusion some years since, and the fact was published by Sir William Dawson in his paper on "The Geology of the Nile Valley" (Geol. Mag., 1884, p. 298). The specimens are of variable dimensions and somewhat fragmentary; they occur in a soft, green, sandy matrix, accompanied by crystals of selenite, and beneath some beds containing vertebrate remains (*Hippopotamus*, etc.). On account of their striking resemblance to Italian forms they are regarded as of Pliocene age.

Horizon.—Pliocene (probably Astian): in the Lake Deposits of Wadi Natrun at the hill known as 'Moluk.'

Distribution.—Red Sea, etc. (Recent); Tunis, Montpellier, Rhône Basin, Italy (Pliocene), Algeria: Kabylie (Sahelian or Tortonian). Egypt: near Cairo (Fuchs); Moluk Hill, Wadi Natrun. Coll. Geol. Surv. Egypt (No. 327, Box No. 1*a*).

Genus UNIO, Retzius (Philipsson), 1788.
Nova Testaceorum Genera, 1788, p. 16.

Type.—*Mya margaritifera*, Linnæus.

Unio Willcocksi, sp. nov. (Pl. XX, Figs. 1–4.)

Unio 'lithophagus' (?), S. P. Woodward: Quart. Journ. Geol. Soc., vol. xx (1864), p. 19 (list name only, no text); *non* (Ziegler) Philippi.

Description.—Shell large, elongate, convex, robust, and ornamented with concentric growth-lines, which are more or less rugose according to age; posterior region oblique, produced and decreasing in width, anterior margin rounded and short; ventral area usually with median depression; umbones anterior, small, eroded, without corrugations; left valve possesses two divergent cardinal teeth, with two minor ridges between; posterior lateral teeth elongate.

Dimensions (of a right valve).—Height, 48 mm.; length, 84 mm.; diameter, 17 mm.

Remarks.—This species is closely related to the recent African form of *Unio Caffer*, Krauss ("Die süd Afrikanischen Mollusken," 1848, p. 18, pl. i, fig. 14), but differs in its more elongate shape, the greater length of the postero-lateral teeth, the absence of umbonal wrinkles, and in the more rugose character of its concentric sculpture. One of the present specimens has its umbonal region entirely denuded of the prismatic layer, thereby showing a complete cast of the interior of the early shell in which the pallial line and muscular-scar impressions are clearly discernible. Many years ago Dr. Leith Adams collected some *Unios* from the alluvial deposits of Nubia at a height of 150 feet above high Nile at the Second Cataract, which the late Dr. S. P. Woodward identified as *Unio 'lithophagus'* (?), but gave neither description nor figure. An examination of these shells in the Geological Society's Museum has proved the fact that they are precisely the same as the species now described, but as they differ from *U. lithophagus*, which is a manuscript species of Ziegler and equivalent to *U. teretiusculus* of Philippi, it is necessary to establish another name, and therefore that of *U. Willcocksi* is proposed, in recognition of the collector of the specimens, which now form part of the Museum of the Geological Survey of Egypt. It may be of interest to state that *U. teretiusculus* (= *U. lithophagus*) from the White Nile is of much more slender form, of a nearly uniform height throughout, and with no posterior oblique attenuation. In referring to the stratified Quaternary deposits at Ombos (= Kom Ombo), Leith Adams remarks that they measured 80 or 90 feet in height, but so far as he could ascertain yielded no organic remains. Mr. Willcocks' discovery of this new *Unio*, from probably the same spot at about 8 metres above the present high Nile, adds a further interest to this locality. The specimens were found associated with vertebrate remains (reptiles, fishes, etc.).

Horizon.—Post-Pliocene (Fluviatile Deposits).

Distribution.—Nubia: Second Cataract. Egypt: Kom Ombo (= Ombos of Leith Adams), lat. 24° 2′ 30″ N., at about 8 metres (= rather more than 26 feet) above present high Nile. Coll. Geol. Surv. Egypt (No. 647, Box No. 23*b*).

EXPLANATION OF PLATE XIX.

Alectryonia cucullata, Born, sp. Pliocene (Astian ?), Moluk Hill.

Fig. 1.—Front view of two lower valves, united laterally.
Fig. 2.—Back view of a lower valve exhibiting the plications.
Fig. 3.—Fragment of the ligamental region of another lower valve, rather longer than usual, and evidently belonging to an older form than the other specimens.
Fig. 4.—Upper valve, interior.
Fig. 5.—Upper valve, exterior, showing obsolete plications.

Planorbis Pfeifferi, Krauss. Post-Pliocene, near Farshut (× twice nat. size).

Fig. 6.—Profile of shell, showing the aperture.
Fig. 7.—Upper surface of shell, showing the depressed whorls.
Fig. 8.—Under surface of shell, showing the umbilicus and aperture.

Melania tuberculata, Müller, sp. Post-Pliocene, near Farshut.

Fig. 9.—Front view of largest specimen, showing aperture.
Fig. 10.—Back view of the same specimen.
Fig. 11.—Magnified view of sculpture.

EXPLANATION OF PLATE XX.

Unio Willcocksi, sp. nov. Post-Pliocene, Kom Ombo.

Fig. 1. } Interior and exterior of right valve.
Fig. 2. }
Fig. 3.—Interior of a left valve.
Fig. 4.—Exterior of a left valve, showing impression of the early shell.

[Except where otherwise stated, the figures on both plates are drawn natural size.]

NOTICES OF MEMOIRS.

The Islands and Coral Reefs of Fiji. By Alexander Agassiz. (Bulletin of the Museum of Comparative Zoology, Harvard College, vol. xxxiii.) 8vo; pp. 168, with 120 plates. (Cambridge, Mass., U.S.A.; May, 1899.)

PROFESSOR ALEXANDER AGASSIZ deserves the thanks of all naturalists for this splendid contribution towards the recently much disputed subject, the origin and mode of formation of coral reefs. This is an age of critical examination, and no man, however beloved and esteemed amongst his fellow scientific men, can propound a theory which shall long remain unchallenged. That Darwin's theory remained accepted and undisputed for fifty years speaks well for the careful and thoughtful observations on which it was based, and, like all the work of this illustrious naturalist, it commended itself to everyone by its clearness and simplicity.

Before proceeding to give an account of his expedition to Fiji Alexander Agassiz devotes a few pages to an examination of some of the literature of coral reefs.

THE LITERATURE OF CORAL REEFS.

"In many quarters" (writes Agassiz) "it has become a question of creed to uphold the Darwinian theory of subsidence as essential to the formation of atolls and of barrier reefs. Facts and arguments supporting other explanations are ignored or explained away in the most extraordinary manner. Regions which are cited by Darwin and Dana as typical become exceptions when shown to be no longer characteristic regions of subsidence. Typical barrier reefs become patch reefs, atolls are dubbed pseudo atolls; so that the regions where true barrier reefs or typical atolls, which owe their origin to subsidence, can be examined, are little by little becoming very restricted. In fact, if we are to judge of the regions not yet examined, and which have not been examined by Darwin and Dana, there remain as extensive regions of possible subsidence only such islands as the Marshall and Carolines, some of the atolls of the Gilbert and Ellice groups, and of the Paumotus. Yet, judging by analogy, of the adjoining districts of Fiji and Tonga, and of the descriptions given by Dana of the Paumotus, and by what we may gather from the charts in the light of our own exploration, it would not be launching a very doubtful proposition to assert that even in these island groups we shall find that the explanation we have given of the formation of atolls and of barrier reefs applies equally well to them. This still leaves the field open for observations in some of the coral regions of the Indian Ocean, and of the East Indian Archipelago. But in the districts which have been described as typical by both Darwin and Dana, recent observations have shown that other and more natural explanations than the theory of subsidence are sufficient to account for the formation of atolls and of barrier reefs.

"As is well known, Darwin's experience among coral reefs was limited to a part of Tahiti, to the west side of Mauritius, and to the Keeling Atoll. Though he passed through the Paumotus without examining any of the islands; according to the narrative of the 'Beagle,' Darwin saw in the distance Honden Island, passed by Taiaro along the shore of Kauehi and sailed between Elizabeth Island and Fakarava (Wittgenstein) to Otaheite. Captain Fitzroy also sailed through the Navigator, Friendly, and Fiji Islands without anchoring anywhere. Dana worked among the reefs at Tahiti, Samoa, and the Feejees, though he did not visit the Eastern Archipelago, limiting his observations to the larger islands, Viti and Vanua Levu and Ovalau. He 'twice visited the Hawaian Islands, landed and gathered facts from fifteen coral islands, some of them in the Paumotu Archipelago; one, Tongatabu, in the

Friendly group; two, Taputeaua and Apia, in the Gilbert group, and five others near the equator, east of the Gilbert group; Swain's Fakaofu, Oatafu, Hull and Enderbury Island, as well as the reef region of the Sooloo Sea and of the Straits of Malacca.'

"In my account of the coral reefs of the Sandwich Islands, I have given a short résumé of the results of the principal investigations on coral reefs since the days of Darwin and Dana down to 1889. What has been done since that time will be found referred to in Bonney's edition of Darwin's Coral Reefs,[1] in Kent's 'Great Barrier Reef,' in Langenbeck's sketches of recent work on the subject, as well as in the reports of the explorations I have carried on in the Bahamas and Cuba, the West Indies, Florida, and the Bermudas in the Atlantic, and of the expeditions I have made to the Galapagos, the Great Barrier Reef of Australia, and Fiji.

"An excellent account of the Samoan Reefs has been published by Dr. Krämer, supplementing the earlier short notice of Dr. Graeff on the reefs of the group; also interesting notes by Admiral Wharton, on Submarine Banks of the Pacific. A careful account of the geology of the Friendly Islands by Lister, published in 1891, seems to have escaped the attention of writers on coral reefs. A few notes on the reefs of some of the islands of the Bismarck Archipelago have been published by Dr. Dahl, but the evidence he gives does not seem to me to warrant his conclusions. The great thickness of elevated reef he found (570 m.) may (as is the case elsewhere in the Pacific) not belong to the present epoch, as he takes it for granted, and no one supposes that elevation has necessarily always taken place uniformly either in time or space over any great stretch of territory.

"The articles by Heilprin and by Ortman on what they call 'Patch Reefs,' do not seem to me to have any special bearing on the general theory of coral reefs. The existence of such 'patches' has long been known and referred to by Darwin, and by many writers on coral reefs, as reef patches. These patches occur in localities where fringing reefs for local causes would not flourish except at a little distance from shore and play a very subordinate part in the physiognomy of the coast. I am at a loss to understand the statements of Ortman regarding the reefs of Kaneohe Bay on the north shore of Oahu. The accurate observations of Hartt and of Rathbun on the moderate thickness of coral reefs off the coast of Brazil seem to have escaped Heilprin and Ortman, as well as other writers on coral reefs. Rathbun has described the reefs along the Brazilian shore, and finds them all as 'having very little height, but from the surface looking like massive structures.' Hartt and Rathbun have described the formation of extensive coral patches and the mode of building up columnar masses which may eventually reach the surface forming mushroom- or even bell-shaped structures, of which enlarging rims may meet, 'resulting in the formation of a connected reef surface supported by many upright pillars underneath from forty to fifty feet high,' the so-called 'chapeirões' of the Portuguese. These patches frequently occur near the shore along the margin of a fringing reef, but are best developed in the deeper water of the Abrolhos regions and between these and the city of Bahia, growing upon the submerged rocky ledge. The number of reef building corals in Brazil is quite small, and Nullipores seem, according to Rathbun, to play a very important part in the building up of the limestone reefs.

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[1] Professor Bonney ("Coral Reefs," Darwin, 1889, 3rd ed., Appendix ii, p. 290), has evidently confounded the views of Professor L. Agassiz on the extent of the formation of the southern extremity of Florida by coral reefs, dating back to 1854, with those which I have published in 1877, in 1880, in 1888, and again in 1896. Neither Dall or Heilprin has examined the Florida reefs; their studies have been devoted to other parts of the peninsula, and did not extend south of the northern limit of the Everglades. Their criticisms in both cases apply to the views of Professor L. Agassiz, as my observations were limited to the reef region, and did not encroach on the area examined by Dall or Heilprin. But I have plainly shown by the borings at Key West that the recent coral formation is of moderate thickness, not more than about fifty feet, and that it is underlaid by a substratum of Tertiary limestones, occasionally coralliferous, of a thickness of nearly two thousand feet. The area probably covered by the coral reef of Florida at the time of its greatest expansion is approximately shown on plate xvii, Bull. Mus. Comp. Zoöl., vol. xxviii (1896), No. 2. I never made the statement quoted by Bonney that the recent coral reefs extended over any part of Florida north of the Everglades. On the contrary, I said in the conclusion of my memoir on the Tortugas and Florida Reefs (Mem. Am. Acad., vol. xi, 1883, p. 116), "All this evidence tends to show that the coral reefs had little, if anything, to do with the building up of the peninsula of Florida, north of Cape Florida."

"Professor Bonney summarizes the position of the theory of coral reefs as now left (1889) in the following terms: 'That this theory may have been expressed in terms a little too comprehensive, that there may be a larger number of exceptional cases than was at first supposed, is quite possible. . . . . It may very possibly be found that, as remarked by Mr. Bourne, the history of coral reefs is more varied and complicated than was at first supposed, but it seems to me that, as the evidence at present stands, it is insufficient to justify a decision adverse to Mr. Darwin's theory as a general explanation.'

"Professor Bonney, in spite of his intention to present an absolutely unbiassed expression, has, in common with most geologists not familiar with coral reefs, retained the view of the correctness of Darwin's theory. It can scarcely be said that the earlier examinations of coral reefs were made with the detail which has characterized the later explorations. The original work of Darwin was limited to a narrow field, and supplemented by data derived from charts and descriptions. Its correctness depends wholly upon the existence of masses of coral reefs of great thickness, where coral reefs exist as barrier reefs or atolls, and having assumed this the rest naturally followed. For no one will deny that subsidence is one of the possible modes of formation of masses of limestone of great thickness. But subsequent observers showed most distinctly that both atolls and barrier reefs occurred in regions of elevation. These exceptions are not limited to a single area. They occur in regions of the globe widely separated. While it undoubtedly is true, as remarked by Professor Bonney, that Darwin has noticed most of the causes on which stress is laid by his critics, it should also be remembered that Darwin did not observe the phenomena subsequently examined, but merely suggested them as possibilities, and his critics may be excused for giving their observations a relatively greater value than to his theoretical views.

"The whole argument of the great thickness of coral reefs based upon the analogy of the so-called raised reefs of Cuba, described by Professor Crosby and myself, or of the fossil reefs, is of little value, as it has been pretty conclusively shown that these elevated reefs, not only in Cuba but in the Pacific, are beds of Tertiary limestone intercalated with beds of moderate thickness in which corals are found, and the same is true of older fossil reefs. Furthermore, these huge masses of Tertiary limestone which form the substratum upon which both in Cuba and in the Pacific recent corals have found a footing, have played no part in the shaping of the barrier or encircling reefs, or atolls, which, as we have attempted to show, owe their origin in the main to mechanical causes.

"Professor Bonney states that 'Much stress is laid upon the fact that many coral islands afford evidences of a certain amount of upheaval; this amount, in most cases, is but slight, and its significance appears to me to have been exaggerated'; and he considers these indications to prove only oscillation. As far as the Fijis are concerned, the elevation extended over the whole group, and has been shown to amount to more than a thousand feet. In Australia it extended along the whole east coast of Queensland for more than a thousand miles, and was more than twenty-five hundred feet in height! He further says, 'If the coral reef be only a sort of cap concealing a hill of pre-existent rock, we may reasonably be surprised that the "ashlar rock" of coral limestone has in no case so far yielded to the action of the atmospheric agencies as to lay bare its inner support.' We can answer this point most decidedly. In Florida the substratum underlying the recent coral reefs crops out at many places, and the highest points of some of the Keys consist of it. So do some of the hummocks in the southern part of the Everglades near Key Biscayne. In the Bermudas the greater part of the land of that group consists of the æolian rocks which underlie the recent coral reef. In the Bahamas the same is the case, and along the northern coast of Cuba the Tertiary limestone forming the substratum of the recent reefs crops out in all directions, while in Australia rocks underlying the Great Barrier Reef can be traced as islands, islets, or negro-heads all along its line for more than a thousand miles. Finally, in the description of the islands of Fiji this substratum appears over and over again, either composed of volcanic rocks or of great Tertiary limestone banks. No better example can be found of the appearance of the substratum of the recent reefs than in Kaneohe Bay, Oahu, at the Sandwich Islands, where the reef is studded with islets and negro-heads consisting of volcanic rocks.

"That corals grow in lagoons is well ascertained, and nowhere is it better seen than in Fiji, where nearly all the islands enclosed by barrier reefs are edged with fringing coral reefs. But why that should prevent a lagoon from being formed I cannot see. A lagoon is not bounded by a reef forming a closed wall rising well above the level of the sea. The greater part of the reef of many a lagoon of an atoll or barrier reef has from two to three fathoms of water upon it at high tide. The reef is also riddled on all sides with narrow channels or openings with from one to two fathoms or more at low tide, in addition to the wider and deeper passages to leeward, through which access is gained into the lagoon. But for all this the lagoon exists, while it may not have more than a few fathoms in maximum depth. This, however, does not prevent the coral heads on the inner slope of the reef from gradually becoming connected with the reef, and from encroaching little by little, but very slowly, upon the outer margin of the lagoon to a depth of seven or eight fathoms, at which the growth is checked either from the sediment accumulating on the floor, or from the strength of the currents scouring the bottom of the lagoon. The amount of dead coral which is ground up upon a reef flat is considerable. Much of it is cemented together and forms a breccia in the cavities of the coral heads, or in the open spaces between them. Still more of it is changed into sand and mud, which cover the floor of the lagoons of barrier reefs and of atolls, and finally a quantity is carried off in solution after the dead coral has become thoroughly rotten and crumbling.

"Darwin also visited the western side of Mauritius, where, he says: 'It is probable that a reef on a shelving shore, like that of Mauritius, would at first grow up not attached to the actual beach, but at some little distance from it; and the corals on the outer margin would be the most vigorous. A shallow channel would thus be formed within the reef, and this channel could be filled up only very slowly with sediment, for the breakers cannot cut on the shores of the island, and they do not often tear up and cast inside fragments from the outer edge of the reef, while every streamlet carries away its mud through breaches in the reef. . . . . A fringing reef, if elevated in a perfect condition above the level of the sea, would present the singular appearance of a broad dry moat bounded by a low wall or mound.'

"Darwin, when meeting Semper's objection that the existence of atolls or barrier reefs in a region of elevation was a fatal argument against his (Darwin's) views, is obliged to say that therein 'seems to me no improbability in their having originally subsided, then having been upraised . . . . and again having subsided.' He further says, 'The existence of atolls and of barrier reefs in close proximity is manifestly not opposed to my views.' Certainly not, but their existence in an area of elevation as claimed by Semper is. Darwin also says that, 'When the land is prolonged beneath the sea in an extremely steep slope, reefs formed there during subsidence will remain closely attached to the shore, and will be undistinguishable from fringing reefs.' This seems to me impossible. The disintegration of the inner edge of the fringing reef, the action of the sea upon this disintegrated material, the solvent action of sea water, all will tend to form a channel between the outer parts of the reef and the shore, as is evidently the case in almost all fringing reefs, which show either an incipient channel where boats may circulate at high water, or a belt of considerable width in which the coral fringing the land has been killed by the silt brought down from the adjacent slopes, and has been decomposed, and, crumbling to sand or mud, is gradually being carried off at each high tide, forming a channel which when wide enough and deep enough becomes sufficiently prominent to change the fringing reef into a barrier reef.

"The difficulties encountered in attempting to meet the many suggestions made by Darwin regarding reefs which he did not examine are well exemplified in the account which he gives of Rose Island, one of the Samoa group.

"Bonney similarly takes Dana's account of the eastern half of the Fiji Archipelago, as if it were based upon actual observations. Dana did not visit that part of Fiji, but derived his information from the surveys of these islands made by the officers of the United States Exploring Expedition. His statements are derived from the charts."

General Sketch of the Fiji Islands and Coral Reefs.

The following is a general sketch by Professor Alexander Agassiz of the Fiji Islands and coral reefs:—

"I went to the Fijis under the impression that I was to visit a characteristic area of subsidence; for according to Dana and Darwin there is no coral reef region in which it is a simpler matter to follow the various steps of the subsidence which has taken place. Dana, in his last discussion of the coral reef question, states that it is impossible to find a better series of islands than the Fijis to illustrate the gradual changes (brought about by subsidence) which take place in transforming a volcanic island with a fringing reef to one with a barrier reef, or to one with an encircling reef ring, and finally to one in which the interior island has disappeared and has left only a more or less circular reef ring. For these reasons one of the Fiji atolls promised to be an admirable location for boring and settling the question of the thickness of the coral reef of an atoll.

"My surprise was great, therefore, to find within a mile from Suva an elevated reef about 50 feet thick, and 120 feet above the level of the sea, the base being underlaid by what is locally called 'soapstone,' a kind of volcanic mud. The western extension of this reef can be traced at points along the north side of the harbor of Suva, the islands of Lambeko, Vuo, and Dra-ni mbotu, which are respectively sixty to seventy feet in height, being parts of an elevated reef extending to low water mark, and now planed off. It was this elevated reef or its extension westward which we traced from the Singatoka River to the Nandi Waters. A short distance inland from the mouth of the Singatoka there is a bluff of about 250 feet in height, composed of coralliferous limestone. This bluff is the inner extension of the elevated patches and limestone bluffs visible on the shore of Viti Levu. I am informed by Dr. Corney that the islands of Viwa and Asawa i lau, to the northward of the Nandi Waters, are also remnants of this elevated limestone.

"But the traces of extensive elevation are not limited to the island of Viti Levu. I found that the islands on the rim of the atoll of Ngele Levu consisted entirely of coralliferous limestone rock, elevated to a height of over sixty feet on the larger island. The northern sides of the smaller islands Taulalia and Tai ni mbeka, as well as the north shore of Ngele Levu, were on the outer edge of the rim of the lagoon, deep water running up to the shore line. We next found that at Vanua Mbalavu the northern line of islands were parts of an elevated reef, forming vertical bluffs of coralliferous limestone rock which had been raised by the central volcanic mass of the main island to a height of 510 feet at Ngillangillah, at Avea to 600 feet, at the Sovu Islands to 230 feet, and on the main island to a height of nearly 600 feet, while on the south of the main island the coralliferous limestone bluffs are very much lower, and those of Malatta and of Susui reach a height of 420 to 430 feet. Going farther west and south we find at Mango vertical bluffs of an elevated coralliferous limestone of over 600 feet underlaid by volcanic rocks at the sea level. At Tuvuthá the limestone bluffs are probably nearly 800 feet high. At Naiau they are more than 500 feet. At Lakemba they reach a height of about 250 feet on the south-west side of the island, the greater part of the rest of the island being of volcanic origin. On the island of Aiwa the elevated limestone is fully 200 feet thick. In the Oneata group the highest point of the elevated bluffs is about 160 feet. South of the volcanic island of Mothe and enclosed within the same barrier on the island of Karoni, the reef is about 120 feet thick.

"On the three islands of the Yangasá group the elevated limestone attains a thickness of 240, 300, and 390 feet, and on Ongea, the most south-easterly cluster we visited, it attains a thickness of nearly 300 feet. At Fulanga the elevated limestone attains a thickness of 360 feet, at Kambara it is about 200 feet thick, and at Wangava it is perhaps over 300 feet; these islands may be in part volcanic. Finally, at Vatu Leile, the most westerly island we examined, the elevated reef forming the island is fully 110 feet thick.

"All this plainly shows that the western and southern part of Viti Levu, as far south as Vatu Leile, and the whole length of the windward islands of the Fiji group, from Ngele Levu on the north to Ongea on the south, have been subject to an elevation of at least 800 feet; and there is abundant proof that the greater part of the thickness of the elevated coralliferous limestones has been eroded so as to reduce it in certain localities to the level of the sea, or in others to leave the bluffs and islands and islets of limestone which we have traced at so many points.

"Unfortunately there are as yet but few soundings among the islands of Fiji. There is a line extending from Nanuku Passage to the Kandavu Passage, and a number of soundings to the north of Wailangilala and towards Thikombia, which have developed the existence of an extensive plateau with a depth of between 300 and 400 fathoms, from which rise all the islands forming the north-eastern extremity of Fiji. The soundings between Ngau and Viti Levu also indicate shallower water to the west of that island than is found either east or south of it. The deep water extends north-westerly in the passage, parallel with Kandavu. Deep water (1,200–1,700 fathoms) is found in the triangle formed by Moala, Totoya, and Matuku, showing the steep slope of Moala, from 1,200 fathoms at a distance of six miles, and of Matuku of 1,400 fathoms at a distance of five miles.

"The deep channel passing through the centre of the Koro Sea gradually deepens towards the south until it attains a maximum depth of over 1,400 fathoms east of Nairai and Ngau, becoming shallower towards Viti Levu. The water gradually deepens also in the Kandavu Passage from over 1,100 fathoms north of North Astrolabe Reef to over 1,900 fathoms south-west of Kandavu. The soundings to the north of Naitamba indicate a ridge with somewhat over 500 fathoms in depth connecting the plateaus on the two sides of Nanuku Passage. There are no soundings showing the depths between the larger clusters composing the Lau or eastern group of Fiji. It would add greatly to our knowledge of the connection of these groups to have lines of soundings connecting the different island clusters of Lau.

"All the evidence to be gathered in Fiji tends to prove that preceding the present epoch there was an extensive elevation, which lifted the great masses of coralliferous limestone resting upon the flanks of the islands to a considerable height, in some cases as high as 1,000 feet. The base of the limestone masses rests upon volcanic rocks, as can be seen at Suva, at Kambara, at Mango, at Lakemba, at Naitamba, and at Vanua Mbalavu it shows the thickness of the elevated reefs to have been over 800 feet. During this period of uplift the physiognomy of the islands of the group must have been greatly changed, and still further modified by the denudation and erosion which have taken place since the elevation of the ancient limestones. It is to the changes brought about by the elevation and the subsequent erosion and denudation that we must look for the causes which have fashioned the steep slopes of the islands and reefs, and not to the growth of the thin crust of corals which thrive upon the reef flats forming the substratum of the modern reef—a substratum which in Fiji may be of volcanic origin or composed of elevated limestone, the sea face of which is the extension of the former land mass and follows its ancient slope, being only slightly modified by the growth of the crust of recent corals found upon it.

"Similar elevated reefs (probably composed of the same Tertiary limestone as those of Fiji) have been described by Clark at the Loyalty Islands, and also by Chambeyron and Pelatan. Chambeyron gives figures of the elevated terraces of Lifou and Ouvea composed of coralliferous limestone, and there is an excellent photograph taken by Pelatan of the elevated coral reefs of Lifou, and reproduced in Bernard's 'Nouvelle Calédonie,' p. 45. While

Maré is said by Pelatan to have five terraces of elevated coralliferous limestone, and to be riddled with caverns, Clark considers the elevated coralliferous limestones of the Loyalty Islands probably to be Pleistocene.

"In the Solomon Islands Guppy has traced extensive elevated reefs, which, however, he considers as belonging to the present epoch. Elevated coralliferous limestones also exist in the New Hebrides, as well as on the southern shore of New Guinea.

"The time of this Fijian elevation we cannot at present ascertain. It is not unnatural to assume that it was coincident with the elevation of Northern Queensland, and that the area of elevation included New Guinea, the islands to the east of it as far south as New Caledonia, and as far east as the most distant of the Paumotus (Gambier Islands), and extended northward of that line to include the Gilbert, Ellice, Marshall, and Caroline Islands; and that since this epoch of elevation the islands within that area have been, like Northern Australia, subject to an extensive denudation and erosion, many of them being reduced to mere flats but a few feet above the surface of the sea, others worn away to represent to-day but a small portion of their former extent. It is upon the reef flats thus eroded, or around the islands and islets which are the remnants of a former period, that the corals of to-day have obtained a foothold. And further, by the mechanical action of the sea combined with that of the trade winds, channels have been excavated out of the substratum underlying the coral reefs to form the lagoons of the barrier reefs and atolls of Fiji.

"So that, as far as we can judge from the case of the Fiji Islands, the shape of the atolls and of the barrier reefs is due to causes which have acted during a period preceding our own. The islands of the whole group have been elevated, and since their elevation have, like the northern part of Queensland, remained nearly stationary, and exposed to a great and prolonged process of denudation and of aerial and submarine erosion, which has reduced them to their present height; the submarine platforms upon which the barrier reefs have grown being merely the flats left by the denudation and erosion of the central island, while the atolls are similar flats from the surface of which the islands have at first disappeared and the interior parts of which have next been removed by the incessant scouring of the action of the sea, the ceaseless rollers pouring a huge mass of water into the lagoon, which finds its way out of the passages leading into it or over the low outer edges of the lagoon. These atolls and islands, surrounded in part or wholly by encircling and barrier reefs, have not been built (as is claimed by Dana and Darwin) by the subsidence of the islands they enclose. They are not situated in an area of subsidence, but, on the contrary, in an area of elevation. The theory of Darwin and Dana is therefore not applicable to the Fiji Islands.

"The evidence of elevation is not limited to that furnished by the remains of the elevated coralliferous limestone just mentioned, and *it is* natural to assume that the elevation we have just traced was but a part of a more general elevation, which perhaps took place in late Tertiary times, and in which the whole group was involved. It is plain that there must have been most extensive denudation and submarine erosion going on throughout the group for a very considerable time, geologically speaking. The outlines of the islands, deeply furrowed by gorges and valleys, the sharp or serrated ridges separating the valleys, the fantastic outlines of the peaks and chains of Viti Levu, Vanua Levu, and Ovalau, all attest to the great work of atmospheric agency which must have been going on for so long a period.

"The extent of the separation of the islands, islets, or isolated rocks from the points or spurs of the larger islands also bears witness to the great length of time during which submarine erosion and denudation have been at work.

"The platforms of submarine erosion constitute the characteristic features of the islands of Fiji. A glance at the sketch map of Fiji and at the detailed charts of different portions of the group cannot fail to show how extensive this action has been.

"Add to this the fact that we are in a region of a former powerful and extensive volcanic activity, the traces of which can still be seen in all directions, and which has undoubtedly played a great part in the lifting of the island masses and their subsequent shaping to their present outlines. From this evidence I am inclined to think that the corals of to-day have actually played no part in the shaping of the circular or irregular atolls scattered among the Fiji Islands; that they have had nothing to do in our time with the building up of the substructure of the barrier reefs encircling either wholly or in part some of the islands; that their modifying influence has been entirely limited in the present epoch to the formation of fringing reefs; and that the recent corals living upon the outer margin of the reefs, either of the atolls or of the barriers, form only a crust of very moderate thickness upon the underlying base. This base may be either the edge of a submarine flat, or of an eroded elevated limestone, or of a similar substructure composed of volcanic rocks, the nature of that base depending absolutely upon its character when elevated in a former period to a greater height than it now has; denudation and erosion acting of course more rapidly upon the elevated coralliferous limestones than upon those of a volcanic character. It is therefore natural to find that the larger islands, like Kandavu, Ovalau, and Taviuni, are of volcanic origin, while the islands which once occupied the area of the lagoons of Ngele Levu, Nanuku Reefs, Vanua Mbalavu, the Argo Reefs, the Oneata, Yangasá, Aiwa, Ongea, and Vatu Leile clusters, were composed of elevated coralliferous limestones. They have disappeared almost entirely, leaving only here and there a small island to attest to the former existence of a more extensive elevated limestone, once covering the whole area of what is now an atoll. Smaller volcanic islands, like Matuku, Moala, Ngau, Nairai, and Koro, also show the greater or smaller extent to which each has been eroded after its elevation, being least in Koro and Matuku, and somewhat more in Moala and

Ngau, and still more in Nairai; while in such volcanic islands with atolls as Mbengha, Wakaya, and Makongai the denudation and submarine erosion have been still greater, the islands covering but a comparatively small area of that once covered by the island originally occupying the area of the lagoon; this denudation having been carried to a still greater extent in the Kimbombo cluster, in Komo, and the islands of Duff Reef. This process of denudation and submarine erosion may have gone so far as to leave no trace in an atoll of its volcanic or of its limestone (elevated) origin, its shape to-day being entirely due to mechanical action, and having nothing to do with the growth of the corals which have found a footing upon the flats due to submarine erosion and to denudation and to the action of the atmosphere and of the sea.

"It seems to me as if the position of an island left on the western or lee edge of a lagoon depended upon the original position of its highest point. This appears in the case of Makongai and Wakaya. The crest of the former was probably near the eastern edge, while the highest point of Wakaya was perhaps nearest the western side of the original island. Similarly the highest summit and ridge of Vatu Leile, if our views are correct, was on the western face of the original land mass. The highest ridge of Rambe lies on the north-western side of the submarine plateau; the islands of Budd Reef indicate its highest land to have been on the northern part of the plateau.

"Admiral Wharton has suggested 'the cutting down of volcanic islands by the action of the sea, and that this action has a far greater share in furnishing coral foundations than has been generally admitted.' From our experience in Fiji we may safely modify this to the cutting down, not only of volcanic islands, but also of other elevated islands, and their cutting down not only by submarine erosion but also by denudation and atmospheric agencies, and thus preparing the foundations upon which recent corals have established themselves. Add to this the elevation of banks composed of volcanic rocks or of sedimentary rocks up to heights at which corals or corallines can begin to grow, and we have in addition to their increment in height from the increase due to pelagic organisms and the decay of other calcareous invertebrates living upon their surface all the elements needed for the preparation of a set of foundations from very different causes.

"I have already on other occasions called attention to the powerful scouring effect produced upon the interior of an atoll or lagoon, or the channel of a barrier reef, by the mass of water poured into it from all sides as the huge ocean swells break over the outer rim. This mass of water can find no outlet against the incessant swell; it must escape to leeward through the openings in the outer reef flats, or laterally over the low parts of their outer edges. It will be noticed that the openings are usually on the west face of the atoll, the direction in which the prevailing trades drive the water of the lagoon. The water becomes charged with particles of lime or of other material, and we soon have all the elements of a modified gigantic pothole, from which the churned material is carried out by the currents flowing through the entrances into the lagoon. It has long been known that there is a violent rush of water out of the lagoons, the velocity attained reaching sometimes four to five knots. In Fiji I have noticed these powerful currents flowing out of the passages leading into the lagoons of Fulanga, of Ngele Levu, of Wailangilala, of Vatu Leile, of Totoya, and racing along the interior channels of the great barrier reef stretching along the south coast of Viti Levu, especially at Lauthala Bay, Suva, and the reef harbors and passages between Suva and Serua, and out of the smaller atolls like Motua lai lai, Thakau Leka leka, Thakau Momo, and others.

"The strength of the currents in the channel separating the barrier reef and the shore has been noticed by Semper and by Möbius as bearing an important part in Mauritius. There is in the *Biologisches Centralblatt*, 1889–90, Bd. ix, p. 564, a short review of the third edition of Darwin's 'Coral Reefs,' showing the principal points in the discussion of the reefs to which Bonney has called attention. But this discussion is mainly theoretical, and adds no new factors in the problem. I would refer to what Gardiner says regarding the conditions affecting the growth of coral reefs in Fiji, where he shows the effect of tidal currents in the passages of reefs and inside of reefs. Strong currents prevent the coral larvæ from fixing themselves in localities which they scour, while the corals will thrive off the passages where the currents have lost their strength. The navigators and naturalists of the U.S. Exploring Expedition frequently speak of the rapid outward current passing through the openings of the reefs, especially during the ebbing tide. Dana had noticed the great strength of the tidal currents, and he well explains by their action the great diversity of distribution of material over the bottom of a lagoon or of a barrier reef channel.

"There seems to be no question that the action of the sea can cut out the lagoons of barrier reefs and of atolls at the depths at which they have been observed in the Fijis. Although there are individual atolls which show depths of thirty-five to fifty fathoms and even more, these are exceptional depths, which are readily explained as due to other causes than the scouring action of the sea.

"Admiral Wharton has given an excellent summary of cases showing to what depths the action of the sea in motion may be felt to a sufficient extent to move material at depths of fifty to sixty fathoms. As he justly says, 'The effect [of the action of the waves in an otherwise deep sea over which strong winds are continually blowing] will be to cut down an island more or less rapidly, according to its constitution, to a very considerable depth below the surface, the final result being a perfectly flat bank.'

"The sections plainly indicate the general flatness of the lagoons, with a slight inclination in the direction of the flow of the water in the lagoon toward the ship passages leading into the lagoon, and the outline of the islands which have first been cut down by atmospheric agencies show irregularities which disappear finally when they have come within the scope of submarine erosion, resulting in such 'sunken' banks as the Penguin Bank. By 'sunken' we do not mean in any way to refer to subsidence as a factor in producing such a bank. The mass of water which is poured into a lagoon on the windward face of a reef, and transforms it into a gigantic pothole, is something enormous. The breakers follow one another incessantly, and the hydraulic head obtained is amply sufficient to account for the scouring of the lagoons after the reef has once established itself as a bank, and amply sufficient to wear away from the slope of the islands the platform upon which the coral reef is built. The topography of this platform is naturally much varied, depending upon the character of the shore line, the direction of the valleys of the shore hills, and their composition. A glance at the charts accompanying this Bulletin will show all possible conditions of submarine erosion in the cutting down of the submarine platforms of the islands of Fiji, and in the manner in which islands, islets, and rocks have been left, attesting their former greater extension in the various clusters of the Archipelago.

"When the principal openings are not on the lee side of the lagoons, as is the case with Vanua Mbalavu, and the Argo Reef or Totoya, Fulanga, and a few others, there is usually a simple reason, such as the lower elevation of the island once covering the area of the lagoon at some point not on the lee side, or the fact that the lagoon has been formed on a steep volcanic slope looking eastward or northward, so that deep ravines or tongues of deep water cut into the lagoons, and intercept the coral patches forming its rim on the weather side, and thus leave a windward passage. It is by some such orogenic condition that we must explain the existence of deep soundings within atolls,—soundings which in no way indicate a subsidence, as has been assumed by Darwin, and which according to him were not to be explained by any other hypothesis. Such deep ravines are of course also to be traced on the slopes of the larger islands where we find, crossing the shallow plateaus on which coral patches grow, valleys of considerable depth, which appear as deep soundings within the area of an outer reef flat such as in the great plateau off Viti Levu and Vanua Levu, or of Kandavu and Taviuni, which according to Darwin would indicate a subsidence, while, on the contrary, they are a part of the results of the elevation and lifting up of that region of Fiji.

"Nor are the great depths found close to narrow lines of corals an indication that the corals have grown up as a nearly vertical wall from a depth of two or three hundred fathoms or more. It merely indicates that the corals form a thin crust, at most 120 feet in thickness, over a sharp volcanic ridge, the summits or crest of which have either reached by elevation the depths at which corals can grow, or have been denuded by submarine erosion to form a platform below the level of the sea, where corals have found a footing upon them.

"My observations in Fiji only emphasize what has been said so often, that there is no general theory of the formation of coral reefs, either of barrier reefs or atolls, applicable to all districts, and that each district must be examined by itself. At least such has been my experience in the Bermudas, the Bahamas, Cuba, Florida, the West Indies, the Sandwich Islands, and Australia. The results of this trip show plainly that Darwin's theory is not applicable to the Fiji Islands, notwithstanding the borings at Funafuti, and that, in all the cases I have examined, the reefs form but a thin crust upon the underlying base, the shape and composition of which is not in any way due to the growth of corals of the existing period."

It is only possible to allude to the clearness and excellence of execution of the charts and the beauty of the illustrations. The work will be sought after and appreciated by all who are interested in the great question of the origin and the formation of Coral Reefs.

REVIEWS.

I.—THE PALÆONTOGRAPHICAL SOCIETY OF LONDON: Annual Volumes (li and lii) for 1897 and 1898. Issued to subscribers of one guinea annually, paid on 1st January to the Hon. Secretary, the Rev. Professor THOMAS WILTSHIRE, M.A., D.Sc., F.G.S., 25, Granville Park, Lewisham, S.E.

THE fiftieth volume issued by this Society, for the year 1896, was reviewed by us in March, 1897 (see the GEOL. MAG., 1897, Dec. IV, Vol. IV, No. 393, pp. 134–8). Since that date, vols. li (for 1897) and lii (for 1898) have been issued to subscribers, and vol. liii, for the present year, might appear at any moment, having already gone to the printers.

The salient points of the monographs contained in the last two years' volumes may now be briefly touched upon.

I.—The fourth (concluding) part of the Monograph of the Foraminifera of the Crag (1897) has been written by T. Rupert Jones, assisted by his highly competent allies, Messrs. H. W. Burrows, C. D. Sherborn, F. W. Millet, and F. Chapman, who have long been authorities on the history of the Microzoa forming the subject of this monograph. This Part (pp, vii–xv, 315–402, woodcuts 24–30; there are seven plates in the foregoing Parts I–III, and their figures are largely elucidated in this last Part) treats of some of the Rotalian group, and all of the known British Nummulinidæ, including several *Nonioninæ* and *Polystomellæ*, and some representatives of *Amphistegina*, *Operculina*, *Nummulites*, and *Orbitoides*, but the specimens of the four latter genera have probably been derived from older strata and left in the Crag of Sussex, whence they were obtained. The whole series of Foraminifera as known fossil in the English Tertiaries is thus completed, as begun in Part I (1866), but restated and continued in Part II (1895) and Part III (1896). Having been carefully collated with past and current rhizopodal literature, this well-illustrated monograph must prove to be a valuable guide to further research. Geologists will fully appreciate Messrs. Burrows and Holland's elaborate "Table of the Distribution of the

Foraminifera in the Crag and in some Contemporaneous Formations in Europe" (pp. 374–394), in which the occurrence of 410 genera and species in the several divisions of the Crag, and of the Pliocene of Belgium and of Italy, and one zone in the south of Spain, are carefully compared.

II.—A Monograph of the British Carboniferous Lamellibranchiata, by Wheelton Hind, M.D., etc. Part II, Mytilidæ, Arcidæ, Nuculidæ; pp. 81–200, pls. iii–xv (1897). The author has devoted time and labour to this useful work. The synonymies of the genera and of their many species are good evidence of this; and the several descriptions show conscientious work. The genera treated of are: *Posidoniella*, De Koninck, 9 species; *Naiadites*, Dawson (8 species were described in the author's monograph in 1895); *Myalina*, De Koninck, 7 species; *Parallelodon*, De Koninck, 22 species; *Nucula*, Lamarck, 8 species; *Nuculana*, Link, 6 species. Plates iii to xv illustrate these forms in abundant detail.

Part III, pp. 209–276, pls. xvi–xxv (1898). The Nuculidæ, continued; *Ctenodonta* has one species. Of the Trigonidæ [rightly Trigoniidæ] we have here *Schizodus*, 4 species; *Protoschizodus*, 13 species. Of the Unionidæ, *Anthracomya* is the type. Edmondidæ supply *Cardiomorpha*, with 9 species. The illustrations are numerous, and aim at the correct definition of all the features of the shells, both in external and internal aspect.

III.—A Monograph of the Carboniferous Cephalopoda of Ireland, by Arthur H. Foord, Ph.D., F.G.S., etc. Part I, Orthoceratidæ; pp. 1–22, pls. i–vii (1897). The author had produced a doctoral thesis with these fossils as its theme, and here the descriptions are reproduced with appropriate and good lithograph illustrations of full size. Grouping them as: A. *Longicones*; Group I, *Lævia*, and sub-Group *Cylindriformes*, he describes 12 species; sub-Group *Moniliformes*, 3 species. Of Group II, *Annulata*, 1 species. Of Group III, *Angulata*, 1 species. Of Group IV, *Lineata*, 4 species. Of Group V, *Imbricata*, 1 species. Most of these are new species.

Part II (1898) contains the concluding part of the Orthoceratidæ, and the families Actinoceratidæ, Cyrtoceratidæ, and the Poterioceratidæ, with 25 pages of letterpress and 10 plates. It is only right to say a word in praise of Mr. A. H. Crowther's excellent and careful lithographic plates of Irish cephalopods, drawn under Dr. Foord's own eyes in Dublin, as they are certainly among the best illustrations which the volumes contain. Dr. Foord's wide experience in the study of Cephalopoda in Canada, in the British Museum, and now in Dublin, renders his monograph of great scientific value to palæontologists.

IV.—A Monograph of the Devonian Fauna of the South of England, by G. F. Whidborne, M.A., F.G.S., etc. Vol. iii, pt. 2: The Fauna of the Marwood and Pilton Beds of North Devon and Somerset (continued); pp. 113–178, pls. xvii–xxi (1897). Some further results of the Rev. G. F. Whidborne's enthusiastic researches among the relics of an old Devonian fauna, badly preserved by nature in the strata of Devonshire, are here given.

Proceeding with the Bivalved Mollusca, he describes one more species of *Parallelodon*, one of *Modiolipsis*, one of *Modiola*, one of *Spathella*, and of *Digoniomya*, a proposed genus. Of the Aviculidæ, he has *Cobracephalus* (provisional), *Leptodesma*, *Leiopteria*, *Ptychopteria*, *Aviculopecten*, *Actinopteria*, *Pterinopecten*, *Crenipecten* (?), *Pleuronectites*, *Pernopecten*, and *Prothyris*. Numerous specimens of Brachiopods have been collected by the author from the strata referred to, and many of them, though distorted, are sufficiently recognizable as species of *Rensselæria* (?), *Athyris*, *Spirifera*, *Spiriferina*. *Rhynchonella*, *Orthis*, *Orthotetes*, *Strophomena*, *Productus*, *Strophalosia*, and *Chonetes*. The extreme care with which the author has come to a decision on the probable and possible affinities of the fossils passing through his hands is highly commendable, and enhances the value of his work very considerably.

In Part III, pp. 179–236, pls. xxii–xxxvii (1898), continuing with the Brachiopoda, we have *Chonetes*, *Crania*, *Discina*, and *Lingula*. Under 'Bryozoa,' which term he decides in an earlier monograph not to be so correct as 'Polyzoa,' but allowable to be used for convenience, he has *Fenestella*, *Pinniretepora*, *Streblotrypa*, *Rhabdomeson*, *Leioclema*, and *Fistulipora* (?). *Cornulites* represents the Annulosa. Of the Echinodermata there are *Lepidestres*, *Protocidaris*, *Palæaster*, *Medusaster*, *Protaster*, *Eugaster* (?), *Ophiurella* (?), *Pentremitidea*, *Codonaster*, *Taxocrinus*, *Rhodocrinus*, *Megistocrinus*, *Mariocrinus* (?), *Actinocrinus*, *Platycrinus* (?), *Adelocrinus*, *Poteriocrinus*, *Scaphicrinus*, *Scytalocrinus* (?), and *Cœliocrinus*. It is pleasant to find among the foregoing several of the species formerly described by Professor John Phillips, but the 'types' of which have been difficult to find until Mr. Whidborne has devoted himself to these Devonian fossils both in quarries and in museums.

V.—In the fifty-second volume (for 1898), we find that Professor T. Rupert Jones and H. Woodward have contributed Part III to their Monograph of the British Palæozoic Phyllopoda (Phyllocarida), devoted to the genus *Dithyrocaris* (pp. 125–176 and pls. xviii–xxv). This genus contains some of the most beautiful forms of *Nebalia*-like Crustaceans, in which the bivalved carapace is borne upon the back of the cephalothorax, with the lateral margins of the valves more or less open, like a dorsal shield, as in *Apus*. The carapace in this genus is variously and beautifully ornamented, sometimes by striæ, sometimes by puncta or reticulate raised lines, in others by scale-like markings, and there are also raised lines and tubercles, reminding one of the ornamentation seen in *Pterygotus* and *Eurypterus*. The dorsal, lateral, and marginal ridges are likewise ornamented in various degrees and form. Abdominal segments, to the number of four, are seen in some examples projecting beyond the posterior border of the cephalothoracic buckler, as in *Nebalia*. These also are ornamented by waved lines, and terminate in three tail-spines, stiff, pointed, and ridged like bayonets. Most of them are of Carboniferous age, and occur in the coalfields of Scotland, Yorkshire, and Lancashire.

VI.—Mr. S. S. Buckman, F.G.S., contributes to the fifty-second volume (1898) Part X of his Monograph on the Inferior Oolite Ammonites of the British Islands, being a supplement to and revision of the Hildoceratidæ; with 4 plates and 32 pages of text. Mr. Buckman observes that "a thorough revision of the genera and species belonging to the family Hildoceratidæ is imperative, for two reasons: (1) because of the large accumulation of material, with so many new forms; (2) because the knowledge concerning the affinities of different species has necessarily become more complete."

If Mr. Buckman can only succeed in making this most difficult subject of the families and genera of Ammonites, such as the Hildoceratidæ, as clear to his readers as it is to himself, he will have earned the thanks of all the members of the Palæontographical Society as well as of geologists and palæontologists in general who attempt to decipher these beautiful and variable extinct Mollusca shell-forms. One result of Mr. Buckman's long study of the group is that he comes to the conclusion that "outward form is of merely subordinate value in classification. It is obvious that species most dissimilar in mere shape[1] can produce, by modification, specimens which are very similar." "Hence some other criteria of affinity must be sought for; and they are to be found in the characters of the ornamentation and suture-lines of the species. In comparison with the mere shape, both these features are constant. They are modifiable and they are modified; but they change so much more gradually than does the mere shape of the conch that they may, for practical purposes, be regarded as fairly stable. At any rate, they change so slowly that their identity is preserved." (p. i.)

In regard to the relative value of the suture-line and the character of the ornamentation as criteria of affinity, Mr. Buckman admits that the former undoubtedly holds the premier place. He contends, however, that in a group like the Hildoceratidæ the ornament is of great assistance.

Mr. Buckman gives tables of his revised system of classification, and we can only express a hope that they will be found capable of adoption by other workers: so shall he have praise of all men.

We congratulate the Secretary, the Editor, the Authors, and the Artists on the output of monographs during the years 1897–98 as reflecting the highest credit on the Palæontographical Society; and we trust that its ranks will be increased by the accession of fresh recruits, so as efficiently to maintain this costly warfare against the still formidable ranks of undescribed British fossils.

II.—The Origin of the British Flora. By Clement Reid, F.R.S., F.L.S., F.G.S. (London: Dulau & Co., 1899.)

THE publication of Mr. Clement Reid's book constitutes a welcome and valuable addition to palæobotanical literature: the volume contains in a small compass and in a clearly-written form the result of twenty years' work. The method of treatment adopted by the author is such as to inspire the reader with confidence; the greater part of the evidence which is adduced being the result of painstaking work by one who has proved himself not only an able geologist, but a keen naturalist, thoroughly equipped by contact with Nature, under varied conditions, to attack the problems which centre round the origin of the British Flora.

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[1] Perhaps the differences observed "in mere shape" may be *sexual*, in that case the offspring would be "very similar."

In the introductory chapter Mr. Reid tells us something of his methods of work: while availing himself of the assistance afforded by the herbaria of Kew and the British Museum, he soon found himself compelled to collect his own material, especially seeds and fruits, to compare with the fragmentary relics of the Pleistocene vegetation. Making the most of his opportunities in the field, the author paid special attention to such biological phenomena as the dispersal of seeds, and other factors concerned in the struggle for existence among our native plants, which might enable him to more satisfactorily interpret the fossil records, and to appreciate the complex agencies connected with the origin of the present flora.

In chapter ii, entitled "The Present Flora of Britain," there are many useful notes on the influence of climatal conditions and other agencies of importance in determining the composition and distribution of the British flora. It is pointed out that Britain shows signs "of a geographical distribution of plants largely independent of that due to climate; or, perhaps we should say, not governed by existing climatal conditions." One of the peculiarities of the present flora, which it is difficult to understand, is illustrated by the occurrence of Pyrenean plants in the West of Ireland and in Cornwall and Devon. In speaking of the woodland flora Reid refers to the probability of such trees as the Horse Chesnut, Spanish Chesnut, Sycamore, Lime, and others, having been introduced by the Romans, who were in the habit of planting trees round their villas for shade and beauty.

The interest of chapter iii, dealing with a subject which, if treated fully, would occupy several times the space allotted to it, is considerably increased by a number of new and interesting facts based on personal observation. The spread of oak woods is no doubt intimately connected with bird-agency; the occurrence of oak seedlings in various situations where no mammal would take the fruits, and other facts, lead the author to conclude that rooks are mainly responsible for the dispersal of acorns.

Long-distance transport of large edible seeds may occasionally be due to rare accidents rather than to special adaptation, as illustrated by the following note:—"Some years ago I found in an old chalk-pit the remains of a wood-pigeon which had met with some accident. Its crop was full of broad beans, all of which were growing well, though under ordinary circumstances they would have been digested and destroyed." The avidity with which some of our native plants occupy a newly exposed tract of ground is neatly illustrated by the following description:—"When the new railway to Cromer was made, the turf and top soil were pared off for a long distance, but nothing more was done for several months. Next summer the route of the line was marked by a scarlet ribbon, which could be seen stretching across the country, the newly-bared sub-soil having been taken possession of by a profusion of poppies."

In chapter iv the author gives an exceedingly interesting but cautious epitome, so far as evidence is available, of the rapid succession of small changes, which characterized the latest stages in the evolution of the British Isles. The reader is warned that the author has been "led to interpret the records somewhat differently from other geologists." The conclusions have not been arrived at without the careful examination of trustworthy data, and many readers will be inclined to agree with Reid's view that the records of mild interglacial epochs are of much greater importance than has been frequently assumed. The Ice Age has undoubtedly been exaggerated as a period of extreme Arctic conditions; it requires but a slight change in a temperate climate to bring about a wide-spread glaciation. It would seem highly probable that during the Pleistocene period the climate was "at least as commonly temperate as Arctic," and at two or more periods there was a sufficient accumulation of snow and ice to convert a temperate into an Arctic climate. This chapter gives us many glimpses of fascinating interest of the waves of life, which swept over Britain during the period of constantly changing conditions between the Pre-Glacial and the Roman age.

Chapter v consists for the most part of lists of plants from various localities, but it is prefaced by a brief account of the conditions under which the seeds, leaves, or twigs were preserved as fossils. A map showing the position of the various localities would have been a great convenience. It would have served a useful purpose if the author had given a more detailed description of the best methods of collecting and preparing the fossil fragments. A collector with the experience of Mr. Reid often forgets the ignorance and inexperience of the layman, who, if properly directed, might easily become an enthusiast, and carry out excellent work in so promising a field as that of Post-Tertiary Botany. In the Stockholm Museum of Palæobotany the writer has had the opportunity of seeing several specimens of Pleistocene plants carefully prepared by Dr. Gunnar Andersson by a method of which a full account has been published in a Swedish journal, and displayed in such a manner as to make the most of the material from the point of view of accurate determination and attractive exhibition. In a department confined to the study of fossil plants, like that presided over by Prof. Nathorst in Stockholm, this kind of work is more easily carried out than in England, where palæobotany has not reached the same level of official recognition.

Chapter vi treats of the former distribution of British plants, but with the exception of four introductory pages the information is given in a form more suitable for reference than for continuous reading. The species hitherto recorded from Pleistocene deposits in *Britain* include not more than one-sixth of the present flora. This fact points rather to the need of further investigations such as Clement Reid has so ably conducted, than to the absence of so many existing species from the Pleistocene vegetation. Only six exotic species have as yet been discovered. As the author suggests, the number of such plants in the Pleistocene flora was no doubt much greater, but the difficulty of obtaining suitable material as an aid to the identification of seeds seriously hampers the recognition of extra-British species. The book concludes with a most valuable list of the plants so far obtained from deposits varying in age from Pre-Glacial to Roman, and it is comforting to find that the botanist may confidently consult the list as one which is very largely based on the determinations of a highly competent specialist.

On first turning over the pages of Mr. Reid's volume, the reviewer was glad to find what he at first took to be a bibliography of works referred to in the text, but on closer inspection he discovered that the publishers had utilized the end of the book as an advertisement of "Books and Pamphlets on British Botany, offered for sale at net prices." A list of papers dealing with Post-Tertiary Geology and Botany, including such works as Warming's excellent memoir on Œcological Botany and others on the distribution of plants, would have been a useful addition.

As already pointed out, Mr. Reid's book bears the stamp of careful and accurate work of the greatest merit; but one feels a little disappointed that he has not given a concluding chapter summarizing in a readable form the evidence at present available from which to draw conclusions as to the origin of the British Flora. Practical hints and suggestions as to the most promising lines of research would have added not a little to the value of the work as an incentive to geological and botanical investigation. One closes the book with a wish for more, and while congratulating the author on his sensible resolve to be as concise as possible and to restrict himself to sure ground, it may be fairly urged that a second edition would benefit by greater fulness and by the addition of one or two more chapters.

It may be asked to what extent does this memoir advance our knowledge as to the origin of the British Flora? The title of the book is perhaps somewhat misleading: the facts it contains may be compared with documents of supreme importance in the construction of a complex genealogical tree; there is much additional evidence which we may reasonably hope to obtain, but much also that we can never discover. The merit of this welcome contribution to our knowledge is, that the evidence it presents is of the highest value, because it is thoroughly trustworthy. To understand the gradual evolution of the British Flora as it exists to-day, we must considerably extend our retrospect beyond the period from which Mr. Reid begins his survey, when practically all the plants seem to have been identical with existing species. Without reflecting on the value of the work, it may be truly said to furnish us with data, much fuller and more valuable than any previously available, towards the compilation of the *past* history of our native plants; but in itself the evidence cannot be regarded as more than sufficient to enable us to form a clearer conception of the latest stages in the development of the British Flora. A. C. S.

III.—The Genera and Species of Blastoidea, with a List of the Specimens in the British Museum (Natural History). By F. A. Bather, M.A., F.G.S., of the Geological Department. pp. x, 70. (London: printed by order of the Trustees, 1899.)

DR. WOODWARD states in the Preface that "this work was originally designed to form one of a series of 'Lists of Types and Figured Specimens,' similar to that issued last year for the Fossil Cephalopoda," but in this comparatively small group it was found possible to extend the work into a list of the Genera and Species of Blastoidea, with an account of the Specimens in the British Museum (Natural History). The scope of the work is well expressed by the author in his Introduction. "First, it attempts to provide a complete index to every name that has ever been applied to a real or supposed Blastoid genus or species. Secondly, it indicates which of those names are now considered valid, and which are believed to be synonyms, giving cross-references from the latter to the former. Thirdly, it cites the literature bearing upon the nomenclature of each species, the bibliographic details being placed under the name now valid. Fourthly, it catalogues all the specimens of Blastoidea contained in the Geological Department of the British Museum (Natural History) at the time of writing (March, 1899). Lastly, it designates more particularly those among them that are of historical interest, as type-specimens or as having been figured, and supplies full references to the literature bearing on each individual specimen."

According to the author the British Museum collection contains 1,223 specimens, representing eighteen out of the twenty-two genera assigned to the Blastoidea; and considering the number of types, figured specimens, and specimens of historical interest in the Museum, we think the author is fully justified in stating that "there can scarcely be any collection so representative of the class as a whole, or so rich in specimens of the highest scientific importance, as is that of the British Museum."

The preparation of such a work entails an enormous amount of tedious labour and research, and every worker in this group will, we are sure, be most grateful to Mr. Bather for compiling, and to the Trustees of the Museum for issuing, such a useful list.

IV.—Bollettino della Società Sismologica Italiana, Vol. IV, 1898.

WITH its 44 national and 9 foreign members, aided by a grant from the Government, the Italian Seismological Society has carried on its useful work for a fourth year. The last volume contains 28 papers.

The invention and improvement of recording instruments continue to engage the attention of Italian seismologists. Dr. Agamennone gives the latest modifications of his electric seismoscope, and apparatus for the same purpose are described by Dr. Cancani and Mr. Guzzanti. Professor Tacchini refers to some old instruments in the possession of the Central Office of Meteorology and Geodynamics, and suggests that they might form the nucleus of a seismometric museum. Dr. Cancani discusses the different methods of registration; discarding the photographic method on account of its expense, he prefers mechanical registration by a fine point on smoked paper to that made by ink flowing from a balanced pen.

There are some useful investigations of recent earthquakes. Dr. Cancani describes the Adriatico-Marches earthquake of Sept. 21, 1897. Dr. Agamennone studies the pulsations of several distant earthquakes, namely, the Indian earthquake of June 12, 1897, the Turkestan earthquakes of August 15 and September 17, 1897, and the Haiti earthquake of December 27, 1897; the two papers on the Indian earthquake being among the most valuable that have yet been published by the Society. Dr. Papavasiliou completes his list of Greek earthquakes in 1897, and also furnishes the catalogue for 1895: work that will without doubt bear fruit in due season. A supplement of 255 pages contains the admirable records of Italian earthquakes (July–December, 1897) compiled by Dr. Agamennone, the chief assistant in the Central Office, and recently appointed to the important post of Director of the Geodynamic Observatory of Rocca di Papa, near Rome.

The newest branch of seismology is represented by two papers, besides those referred to in the last paragraph; one by Professor Grablovitz on the form of the slow oscillations in earthquakes, the other by Messrs. Agamennone and Bonetti on the different methods of determining the position of the epicentre in distant earthquakes of unknown origin.

The volcanic phenomena of the country are as usual the subject of careful study. Mr. R. V. Matteucci writes on the increase in activity presented by Vesuvius during the months of April and May, 1898. Professor Mercalli continues his valuable Vesuvian notices (January, 1897—July, 1898), and Mr. Arcidiacono his equally useful accounts of the principal eruptive phenomena in Sicily and the adjacent islands during 1898. C. Davison.

REPORTS AND PROCEEDINGS.

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Geological Society of London.

June 21, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On a Series of Agglomerates, Ashes, and Tuffs in the Carboniferous Limestone Series of Congleton Edge." By Walcot Gibson, Esq., F.G.S., and Dr. Wheelton Hind, F.R.C.S., F.G.S. With an Appendix on the Petrography of the Igneous Rocks by H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

After referring to the discovery of volcanic rocks in the upper part of the Carboniferous Limestone Series at Tissington, the authors proceed to describe evidence of volcanic action of the same age on the western slopes of Congleton Edge. This ridge is capped by two beds of Millstone Grit separated by black shales. Below the lower grit (the 'Third Grit') is a narrow dome of limestone lying in the midst of so-called 'Yoredale Shales' and exposed in an old quarry. The upper beds of the Limestone consist of thin shales and limestones containing one important and some minor seams of tuff and agglomerate, and certain evidence points to the probability that a 'neck' occurs in the quarry. A brook-section north of the quarry exposes beds of ash and tuff interstratified with shales and limestones, the thicker beds being presumably equivalent to those seen in the quarry. A brook-section south of the quarry displays the beds between the Limestone and the 'Third Grit,' and a small quarry yields a varied marine fauna.

In the Appendix it is stated that the igneous rock of the quarry is either a volcanic agglomerate filling a vent, or a thick deposit of very hard, coarse ash, probably formed not far from a vent. Ashy material in the Limestone indicates that the volcanic action was contemporaneous with the deposition of the Limestone. Two kinds of lapilli occur—one palagonitic, without crystals, and a second doleritic, free from vesicles, and containing felspar, olivine, and often augite; the latter type, though common in the agglomerate, is rarer in the bedded tuffs. The fragments are frequently altered into calcite.

2. "On some Ironstone Fossil Nodules of the Lias." By E. A. Walford, Esq., F.G.S.

In the Lias of Oxfordshire some ironstone-nodules are found at the point of contact of the Middle and Upper Lias. "The Middle Lias stone is compact, crystalline, and absorbent, and contains numerous irregular pyriform bodies," some of which "are changed wholly into a form of red hæmatite. These . . . . bodies have a circular vertical canal or shaft . . . . with the polyp and zooid-cells ranged round in obscure spiral growth. The cells have the areolated structure of the crinoids, or are spiculate of the type figured by Sars in *Pennatula.* Though in form approaching the *Cumacea*, the presence of perforated brachial plates, of annulated segments, and of spiculate zooidal cells, places the group between the *Pennatulæ* and the Crinoids. The resistance of the denser structure of the beds of calcareous stems of the rag-beds has caused the beds above and below them to become the lines of drainage, and hence [to become converted] into beds of greater ferruginous concentration."

3. "Additional Notes on the Glacial Phenomena of Spitsbergen." By E. J. Garwood, Esq., M.A., F.G.S.

This paper contains the results of additional observations on the ice of Spitsbergen made by the writer in 1897. The inland ice visited occupies two distinct areas, separated by Dickson's Bay and

Wijde Bay. The radiating-point lies somewhat north-west of the centres of each area, with supplementary radiating-points on the north and east. The group of peaks including the Three Crowns may be regarded as nunatakkr. The valley-bound ground-ice does not necessarily travel in the same direction as that of the surface. The effect of nunatakkr on the surface of the ice-sheet was studied, and from this it was often found possible to infer the existence and position of buried mountain-ridges. On the stoss-seite of a nunatak moraine-material is often discharged. The movement of the ice has frequently converted the ice-bridges across crevasses into arches and tunnels, some of which carry part of the drainage of the ice-sheet.

Portions of old stranded ground-moraines, formed when the ice was more extensive, were sometimes found to have fallen upon the lowered ice-sheet and to be mingled with modern moraine-material. Englacial and superficial rivers are described, and one of the latter was found to be depositing gravelly material along a line at right angles to the valley down which the ice was flowing.

Certain observations on the rate of movement of the ice-sheet seem to indicate that this is not less than 15 to 20 feet in 24 hours; while the glaciers near the sea-margin appear to be travelling about 25 feet in the same time.

The action of sea-ice is described, and it is inferred that a certain amount of rounding and scratching of shore-rocks, and possibly part of the smoothing of boulders, may be due to this agent.

4. "Additional Notes on the Vertebrate Fauna of the Rock-Fissure at Ightham (Kent)." By E. T. Newton, Esq., F.R.S., F.G.S.

Since the previous paper on the Ightham-fissure fauna published by this Society about five years ago, numerous additional specimens have been obtained, not only by Mr. Lewis Abbott, but also by Mr. Frank Corner and Mr. Kennard.

The present paper gives a very brief account of the new forms which have been discovered and identified during the last five years, with remarks upon some important additional remains of *Mustela robusta*, and of the *Spermophilus* which is now referred to the species *erythrogenoides* of Falconer. This paper adds some 19 new forms to the fauna of the Ightham fissure.

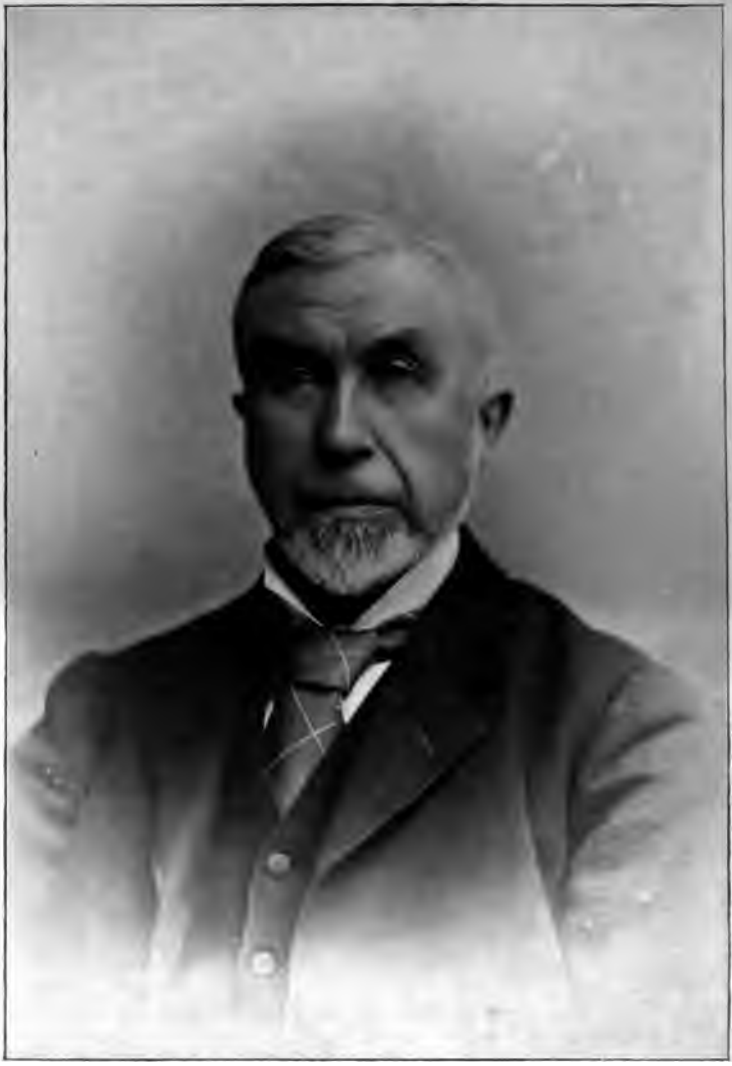
⁂ The next Meeting of the Society will be held on Wednesday, November 8th, 1899.

CORRESPONDENCE.

ROCK-WEATHERING, SERPENTINIZATION, ETC.

Sir,—Both Mr. Merrill and Mr. Holland deserve the thanks of geologists for their suggestive papers on certain forms of rock change, and the distinction drawn by the former (p. 354, Geol. Mag., August, 1899.) between ordinary 'weathering' and more deep-seated changes in rocks is of great importance. The subject is one which my own work has often brought before me, though, as other questions had prior claims, I have never been able to investigate it systematically. And it is one beset with difficulties, especially when we are dealing with rather old rocks, not the least being that of determining when the alteration for which we have to account, has taken place. But I have always tried, so far as was possible, to call attention to any mineral changes which seemed distinctive, and have sometimes ventured to suggest a cause for them. The subject would well repay any young geologist with sufficient leisure, and on this account, with the same motive as Mr. Merrill, I will venture to offer a few remarks suggested by his paper. As regards 'serpentinization' I have come to the same conclusion as himself, viz., that the change is deep-seated rather than superficial, and that the same is true of certain other hydrous minerals, though it may not hold with some at least of the zeolites. But the anomalies which mineral change presents are apparently considerable. As an example we may select the conversion of augite into hornblende. Sometimes a crystalline grain of the former mineral may pass into one of the latter by a change seemingly no more than paramorphic; sometimes it may break up into a group of smaller grains, not retaining exactly the original outline. Sometimes, carrying this further, it may form one or more elongated crystals (this, as I have pointed out, seems connected with pressure); and sometimes it may be converted into a more or less fibrous and matted mass, in which case not seldom some chemical alteration seems to have taken place. Again, as another anomaly, some light-coloured augites seem very stable, as in certain picrites and granites; while others, as in some hemithrenes, change rather readily into serpentine. But in a mica-trap the augite, probably also not rich in iron, seems to be very unstable, not, however, altering to hornblende. In one dolerite the augite seems to change more readily than the felspar, in another the reverse. Felspar sometimes changes into quartz and white mica, sometimes undergoes other alterations. Here, as in some other cases, much probably depends upon whether the water present is 'stagnant' or in motion. It would be easy to continue the list, but this may suffice to give some idea of the problems presented, and when they have been solved we may proceed to those presented by the devitrification of glassy igneous rocks. Suffice it to say that the changes in a mineral seem to be the outcome of two separate causes; one, its chemical composition; the other, its environment, the principal factors in the latter being water, pressure, and heat. The best way of attacking the problems will be by first studying the simpler cases, viz., those in which we can be reasonably certain that one factor in the environment has so far dominated over the others, that they may be neglected; and then proceeding to the more complicated cases. Of this I think we may be certain, that in nature, with the same materials, similar causes produce identical results, and dissimilar causes the contrary.

T. G. Bonney.



Yrs truly
Henry H. Howorth

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. VI.

No. X.—OCTOBER, 1899.

ORIGINAL ARTICLES.

I.—EMINENT LIVING GEOLOGISTS: HENRY H. HOWELL, F.G.S., formerly Director of the Geological Survey of Great Britain.

(WITH A PORTRAIT, PLATE XXI.)

AFTER a term of work extending over nearly half a century, Mr. Howell, the Director of the Geological Survey of Great Britain, has retired from the public service.

It is not often that a man who has only just reached the age-limit of 65 is able to look back on such a lengthened period of official work. No member of the Geological Survey has before attained such a record. Even Mr. Selwyn, whose portrait we gave in our February Number, had reached the age of 70 when he had nearly completed his fiftieth year of work on the Geological Surveys of Great Britain, Victoria, and Canada.

Henry Hyatt Howell was born on the 13th July, 1834, at Prinknash Park, Gloucestershire. He was the fifth son of Thomas Jones Howell, Esq., sometime Judge Advocate at Gibraltar, and Editor of the "State Trials." He was educated partly at the College School, Gloucester, and afterwards in the "Applied Science" Department at King's College, London, where at the time David Thomas Ansted, M.A., Fellow of Jesus College, Cambridge, was Professor of Geology.

In the spring-time of 1850, with an introduction from Colonel James, R.E. (afterwards Sir Henry James, and Director-General of the Ordnance Survey), he was attached (unpaid) to the surveying division of the Sappers and Miners then engaged at Wakefield, in Yorkshire, Captain Tucker, R.E., being in charge of that district. This survey was for the completion of the Ordnance Maps of the Six Northern Counties of England on the six-inch scale.

In the summer of the same year, with Lieutenant Cameron, R.E. (afterwards Director-General of the Ordnance Survey), he was attached to the surveying division then engaged in measuring the base line on Salisbury Plain with compensation bars.

Later on, in September of the same year, with a letter of introduction from Colonel James, he was permitted to join Prof. Ramsay, then Local Director of the Geological Survey of Great Britain, at Llanberis, in North Wales, in order to gain some practical knowledge of geological surveying.

Thus when little more than sixteen years of age he commenced the active study of geology, and it was reported by Ramsay on September 11th, 1850, that at Carnedd Dafydd he "did a glorious day's work with Howell up to Aber, getting all Jukes's ugly bits of sandstone, etc., perfectly explained—a succession of domes cut off by faults. Home at half-past seven—a long, long walk."[1] A little later on young Howell spent a short time with Beete Jukes on the same Survey at Llangollen.

On the 7th October Howell was appointed an Assistant-Geologist "upon the usual course in our service of a six months trial." He, however, gave so much satisfaction in the field while with Professor Ramsay and Mr. Beete Jukes, that the time of probation was shortened to three months, and the appointment was confirmed in a letter dated 1st January, 1851. This was written by Sir Henry De la Beche, who was then Director-General, so that the last link which connected the present staff with the illustrious founder of the Geological Survey is now officially severed.

Aveline, Bristow, Selwyn, Edward Forbes, Salter, and Smyth were then on the staff. Hull had also but recently joined. During his three months of probation Howell was placed at Rugeley with Beete Jukes, who was then engaged in mapping the northern part of the South Staffordshire Coalfield. No more excellent a guide could he have had than Jukes, whose wide experience, ability, and sound judgment made him an excellent teacher, and whose field-work has been a model to all subsequent observers. It was also at this time that Howell was instructed to complete the survey of the one-inch quarter-sheet 72 S.E., which included the outliers of 'Lias' (now known to be the Rhætic Beds) on Needwood Forest.

For several years Mr. Howell was occupied in the survey of the Midland Counties in the neighbourhood of Lichfield, Tamworth, Atherstone, Nuneaton, Coventry, Birmingham, and Droitwich. He also mapped parts of North Gloucestershire, his notes being published in the Geological Survey memoir on "The Geology of the Country around Cheltenham" (1857), by E. Hull, who states that "The districts adjoining the Severn and Avon, together with Bredon Hill and the northern part of the Cotteswold Range as far south as the road between Bourton-on-the-Hill and Snowshill, have been surveyed and described in this memoir by Mr. Howell."

Probably the most important work done at this period (between 1851 and 1854) was the survey on the one-inch scale of the Coalfield of Warwickshire. Howell's memoir on "The Geology of the Warwickshire Coalfield and the Permian and Trias of the surrounding district" was published in 1859, and this gives a concise and excellent account of the Coal-measures and overlying strata. Some changes have since been made in the grouping of the older rocks, the Hartshill quartzite having at the time been regarded as Millstone Grit. This view was not arrived at without considerable discussion. The rock had originally been compared with that of the Bromsgrove Lickey, and both the late Professor Jukes and Mr. Howell were in favour of retaining the beds in the then very comprehensive "Silurian series,"[1] but Sir A. Ramsay (at that time Local Director) was of opinion that the quartzite and overlying shales should be included with the Carboniferous. The subsequent researches of Professor Lapworth and Mr. W. J. Harrison (1882) have shown that the quartzite is of Cambrian age,[2] thus generally confirming the view of Jukes and Howell of the antiquity of the quartzite.

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[1] Geikie's Memoir of Ramsay, p. 167.

Apart from the interesting but often arduous work of mapping there was much other work to be done: the districts surveyed by Mr. Howell were illustrated by many sheets of vertical sections, and also of 'horizontal' or longitudinal sections drawn to a natural scale of six inches to a mile. The task of producing these longitudinal sections was in old days a tedious and troublesome one, requiring great care and skill. Nowadays with the contoured six-inch maps the surveyor can readily plot his sections in the office. Then he had to traverse the ground with theodolite and chain, and to conduct his operations with the aid of a couple of men.

In many instances the horizontal sections were accompanied by short descriptive pamphlets (price 2*d.*), and in these (e.g., Explanations of Sheets 46, 48, 50, 51, and 57—all published in 1859) we find many notes on the strata examined and mapped by Mr. Howell. He was also joint author with Mr. Aveline of a short memoir on "The Geology of part of Leicestershire" (1860).

In the autumn of 1854 the Geological Survey of Scotland was commenced by Ramsay in the neighbourhood of Dunbar. His Directorial duties, however, prevented him from accomplishing very much field-work, and in consequence Mr. Howell was transferred to Scotland, and commenced work there in 1855. In course of time he surveyed large areas in the counties of Berwick, Haddington, and Edinburgh, his chief work being the mapping of the Mid and East Lothian and Fifeshire Coalfields.

In the same year (1855) Mr. Howell was joined by Mr. (now Sir) Archibald Geikie (the present Director-General), who, "after some months of field-work with Mr. Howell in continuing the Director's mapping in East Lothian, began the survey of Midlothian in 1856."[3] A joint work on "The Geology of the Neighbourhood of Edinburgh," by H. H. Howell and Archibald Geikie, was published in 1861. The descriptions of the Midlothian Coalfield and chapters on the Millstone Grit and Coal-measures were written by Mr. Howell. Meanwhile, in 1857, Mr. Howell had been promoted to the rank of Geologist. Later on (in 1861) John Young, M.D. (now Professor of Natural History in the University of Glasgow) joined the staff, and he aided the field-work in Scotland. In 1866 the memoir on "The Geology of East Lothian," by H. H. Howell, A. Geikie, and John Young, was issued. Several maps on the six-inch scale of the coalfields of Edinburgh and Haddington were also published.

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[1] See Strahan, GEOL. MAG., 1886, p. 541.

[2] Lapworth, ibid., 1882, p. 564.

[3] Geikie's Memoir of Ramsay, p. 244.

The main geological result of the work in these Carboniferous regions of Scotland was the recognition for the first time that the "Roslin Sandstone" was the representative of the Millstone Grit, and occupied the same position as does that formation in the Carboniferous Series of England and Wales. Moreover, it was ascertained that the true Coal-measures, with many workable seams of coal, occurred, as in the Northumberland and Durham Coalfield, at a higher horizon than the Millstone Grit. The same group of rocks as had been found in East and Mid Lothian was shown to extend across the Firth of Forth into Fifeshire.

In 1861 Mr. Howell was transferred again to England, and for the next four years he was occupied in mapping (on the one-inch scale) large areas of Jurassic rocks, chiefly in the counties of Northampton, Bedford, and Huntingdon.

The continuation of this work into Rutlandshire and South Lincolnshire was in after years carried on by Professor Judd, who, together with the late Samuel Sharp, ascertained that the Lincolnshire Limestone, which had been regarded as Great Oolite, was of the age of the Inferior Oolite. On a memorable occasion in 1869 the revised interpretation of the geology was considered by the Director, Ramsay, who visited parts of Northamptonshire with Howell, Judd, Sharp, and Etheridge.

Ramsay, after reviewing the evidence, turned, in his quick impatient way, to Howell to ask why he had regarded the Limestone as Great Oolite? To which Howell replied by quietly pulling from his breast-pocket a list of the fossils which he had collected, and which had been named and referred, in the Palæontological Office, to the *Great Oolite.*

In 1866 Mr. Howell was instructed to commence the geological survey of the Northumberland and Durham Coalfield.

In the following year, when large additions were made to the staff of the Survey, Mr. Howell took the superintendence of a number of the men who were engaged in the Survey of the North-Eastern Counties. At this time the late Prof. A. H. Green took immediate charge of the Yorkshire Coalfield, while in course of time Mr. Howell directed the whole of the work in North Lincolnshire, East Yorkshire, Durham, and Northumberland. In 1869 he was called upon to give evidence on the Northumberland and Durham Coalfield before the Royal Commissioners appointed to enquire into the several matters relating to Coal in the United Kingdom.[1] In 1872 he was promoted to be District Surveyor, the duties of which office he had in fact for a long time been discharging.

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[1] See Report, vol. ii (1871), p. 503.

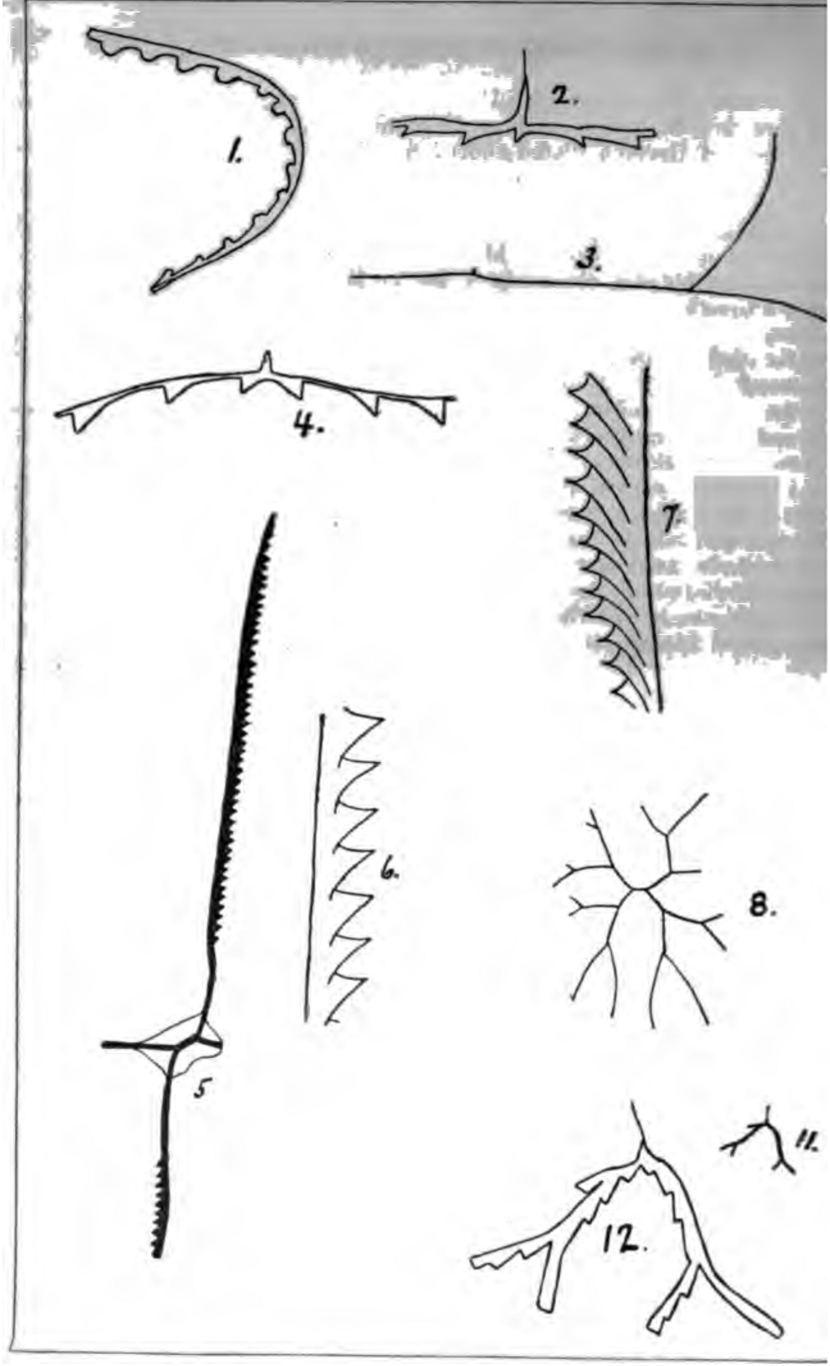
For about sixteen years Mr. Howell was thus busily occupied, partly in carrying on field-work himself, more largely in superintending the work of the staff placed under him. With a number of men of varied ability, energy, and enthusiasm, it is a well-nigh impossible task to carry on the field-work in a strictly uniform manner. The methodical habits and the stern sense of duty inculcated by Mr. Howell proved, however, of inestimable value in the conduct of the Survey, and it may be candidly admitted that no large tract of ground had before been so systematically surveyed and inspected on the Geological Survey. As a field-geologist and administrator no man came to be more highly esteemed by the members of the Survey who had worked under him.

On the retirement of Ramsay in 1882, and when the present Director-General was appointed in his stead, Mr. Howell was made Director for Scotland. About this time several of the more experienced surveyors, who had worked under Mr. Howell in the North of England, were transferred to Scotland. A great change in the methods of mapping was then introduced—changes which have borne excellent fruit in the detailed surveys which have since been carried out in the highlands of Scotland.

When the late H. W. Bristow retired in 1888, Mr. Howell was appointed Director for Great Britain, although his special sphere of action did not extend beyond the northern counties of England, the detailed supervision of the men in the midland and southern parts of England and Wales being relegated to senior geologists. During these later years the mapping of the Isle of Man was commenced and completed under the superintendence of Mr. Howell.

Mr. Howell has added little to the general literature of geology. We have referred to his official labours in maps and sections, in memoirs and explanatory pamphlets, but we have no extended list to add of papers communicated to scientific societies and magazines. We may, indeed, mention one paper published in this Magazine (for 1890, pp. 8–13) entitled "Note on the Classification of the Red Rocks in South-East Durham; and on a possible unconformity between the Trias and the Permian Limestone in the same District."

The fact is that Mr. Howell has given his life to official work, in later years almost wholly to those administrative duties which bring but little praise or reward to the individual, except so far as his guiding hand and advice are seen in the good work accomplished by others. His life has been one of disinterested devotion to the welfare of the public service, and of the men who have had the privilege of working under his direction. We cordially wish him all happiness in the days of his retirement.



Graptolites of Victoria, Australia.

II.—THE GRAPTOLITE-BEARING ROCKS OF VICTORIA, AUSTRALIA.

By T. S. HALL, M.A., Melbourne University.

(PLATE XXII.)

INTRODUCTION.

THE area occupied by Lower Palæozoic rocks in Victoria is an extensive one, and is pretty equally divided between Ordovician and Silurian, the part occupied by Cambrian being small. According to Dr. A. R. C. Selwyn, formerly Director of the Geological Survey of the Colony, the total area amounts to somewhere about 30,000 square miles in extent,[1] and although in this estimate he included all areas occupied by these rocks provided the cover was not more than 350 feet in thickness, it will still leave us with a large extent of country over which graptolites may be found.

The earliest record of the occurrence of these fossils in Victoria is on a map of Selwyn's published in 1856, where it is stated in a note that graptolites were found for the first time in Australia by C. D. H. Aplin in May, 1856, at a locality indicated on the Saltwater River near Keilor, about ten miles north-west of Melbourne. No identifications have ever been made from these beds, which yield a few species of Monograptidæ in a poor state of preservation.

Very shortly after this graptolites were found in the Lower Ordovician rocks of Bendigo. In an essay contributed to the Catalogue of the Victorian Exhibition of 1861, Professor McCoy recorded from various localities several species which included Diplograptidæ, Dichograptidæ, and Dicranograptidæ, as well as *Monograptus ludensis*, which showed that even thus early almost the whole range of graptolite-bearing rocks had been examined.

In a similar essay by the same author published in 1867, a few additional forms were noted.

The first decade of Sir F. McCoy's "Prodromus of the Palæontology of Victoria" appeared in 1874, and contains the earliest figures and descriptions by which we can judge of the accuracy of his previously published determinations. The plates seem to have been printed off several years previously, for Professor James Hall, in his "Graptolites of the Quebec Group," says that he received a plate from Professor McCoy in 1861, and which from his remarks would appear to be one which was not published till 1875. Two years later, in his fifth decade, Professor McCoy issued figures and descriptions of a few more of these fossils. In 1874 Mr. R. Etheridge, jun., published figures and descriptions of several forms which he identified with known species, the date of his paper in the *Annals of Natural History* and of McCoy's first decade being almost simultaneous.

With regard to the determinations contained in these and other early papers, it may be stated generally that, as was the case of many of those of Britain before Professor Lapworth undertook his work of revision, they are in very many cases unreliable. The causes that led to this in the British records have been clearly enunciated by Professor Lapworth, and though it must always appear ungracious to reject any of the work of the pioneers of Australian palæontology, to whom we owe so much, yet the ground must be cleared before a stable structure can be raised. The minute differences on which it has been found advisable to separate the species in this difficult group were not then generally recognized, and we find many of our graptolites identified with forms from which we now regard them as even, it may be, generically distinct. In the case of those forms where the method of branching and the habit is a guide there was, of course, less liability to confusion, and here the specific identifications are of value, but it is extremely doubtful, on the other hand, whether any of the Diplograptidæ have been correctly determined, and a great number of those forms referred to *Didymograptus* (*sensu stricto*) are probably incorrectly identified. One feature, however, must not be overlooked, and this is that the records have in many cases been made from exact localities; and this in the case of Sir F. McCoy's papers, owing to his official connection with the Survey, is of peculiar value, as the precise position from which the fossils came is recorded both by him and on the geological maps, and we are thus frequently enabled to check the records in a very effective way.

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[1] Intercolonial Exhibition Essays, 1866–7: "Notes on the Physical Geography, Geology, and Mineralogy of Victoria," p. 13.

During the past seven years I have published several papers on the group as represented in Victoria, and two have also appeared by Mr. G. B. Pritchard, most of them having been printed in the Proceedings of the Royal Society of Victoria.

In a paper dealing with the occurrence of Lower Silurian (i.e. Ordovician) graptolites in New South Wales, Mr. W. S. Dun[1] gives a list of the more important Australian literature referring to the group.

SEQUENCE.

The general sequence of the Victorian graptolites may be correlated with that of the Northern Hemisphere, but experience has shown that it is unsafe to push the analogy too far, and that the only safe method is that of detailed stratigraphical work. Thus we find forms here associated which elsewhere are separated by intervening zones; and, on the other hand, forms elsewhere associated may be here separated. A form which I have named *Leptograptus antiquus*,[2] and which, though not perhaps a typical member of the genus, is certainly not a *Didymograptus*, occurs on the same slabs as a *Bryograptus*. *Didymograptus bifidus*, again, which in Europe and America is characteristic of Upper Arenig, dies out in Australia long before *Phyllograptus typus* has disappeared, and is also survived by a *Clonograptus* and two or three species of *Dichograptus*. At Lancefield, where our lowest Ordovician rocks occur, *Clonograptus flexilis* and

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[1] Records of the Geological Survey of New South Wales, vol. v (1897).

[2] Proc. Roy. Soc. Victoria, new ser., vol. xi (1899), p. 164.

C. rigidus are found in association with *Bryograptus*, while in Europe and America *Bryograptus* is a Cambrian form, and indicates an age to which its Victorian associates forbid us to refer it here. In the Northern Hemisphere, again, *Clonograptus flexilis* is associated with forms which characterize the next higher horizon with us. The case of *C. rigidus* is also striking, for though in America it is, according to Ami,[1] associated with *Loganograptus*, yet with us the latter genus does not appear till *Phyllograptus typus* and closely allied species have become extinct. These are all striking forms, and although it is of course not impossible that mistakes in identification have been made, yet figures and descriptions of Australian forms referred to these species have been published by McCoy and myself, with the exception of the members of the tuning-fork graptolites.

The stratigraphical evidence on which these statements are founded does not rest on merely a single set of outcrops, for, with the exception of the Lancefield beds, the field relations of which have not yet been worked out, as the conditions are unfavourable, their relative position has been studied in two or three places.

To prove a negative is, of course, not an easy task, and it may be objected that the non-association of some of the forms I have quoted is only due to imperfect collecting. For instance, I have placed the Castlemaine rocks as a whole above those of Bendigo, and both above those of Lancefield, and have never seen *Clonograptus flexilis* anywhere but at Lancefield, where *C. rigidus* occurs as well. A species related to the latter, which, however, I believe to be distinct, ranges up into the lower Castlemaine zones, but never as high as beds which contain *Loganograptus Logani*. This statement is founded on several years' collecting in fairly rich beds at Castlemaine and Bendigo, as well as on the examination of several collections made at the latter place by others, so that the evidence in favour of the facts being as I believe them to be is strong.

The numerous localities at which graptolites occur in Victoria and the vast area over which they are spread render the hope of anything like a complete account of them for some time to come quite out of the question, and all that can be done at present is to give a brief outline of what has been done towards elucidating their sequence. There is not at present sufficient evidence available to do more with the Ordovician rocks as a whole than to divide them into Upper and Lower, the upper division being characterized by the presence of Dicranograptidæ.

The most thorough collecting that has been done is in the older beds of the Lower Ordovician, and even here large areas are almost untouched. The younger beds of the series have not as yet yielded many forms in a sufficiently well-preserved condition for description, while those from the Upper Ordovician occur at widely scattered localities, and the collections made are small and poor. Still worse is the case of the Silurian forms, for they come from some half-a-dozen localities and afford little more than a record of *Monograptus* and *Retiolites*.

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[1] Geol. Surv. Canada, Ann. Rep., vol. iii (1887-8), K, p. 116.

MAIN DIVISIONS OF THE GRAPTOLITE BEDS.

Lower Ordovician.

1. *Lancefield Series.*—The blue black shales of this locality yield a fauna which I have dealt with in some detail elsewhere.[1]

The species recorded are: *Bryograptus Victoriæ*, T. S. Hall; *Bryograptus Clarki*, T. S. Hall; *Leptograptus antiquus*, T. S. Hall; *Didymograptus Pritchardi*, T. S. Hall; *Didymograptus Taylori*, T. S. Hall; *Tetragraptus decipiens*, T. S. Hall; *Clonograptus flexilis*, J. Hall; *Clonograptus magnificus*, Pritchard; *Clonograptus rigidus*, J. Hall; *Clonograptus rigidus*, var. *tenellus*, Linnars; *Phyllograptus*? sp.; *Dictyonema Macgillivrayi*, T. S. Hall; *Dictyonema pulchellum*, T. S. Hall.

There is at first sight a strange intermingling of genera here, but the species are all associated in one small excavation, and no separation of the beds is possible. From the occurrence of *Bryograptus*, which is fairly common, the beds must be regarded as the oldest of our graptolite-bearing rocks yet found, while from the presence of the other associated genera they cannot, I think, be regarded as Cambrian, but must be looked on as Ordovician.

2. *Bendigo Series.*—As far as is known, the greatest development of these beds is in the Bendigo district, where our richest auriferous quartz veins occur. A similar fauna is also found at Chewton, Daylesford, Tarilta, Newstead, Spring Plains, Upper Loddon, and near Lancefield.

Minor subdivisions in this thick series will doubtless be made, but at present no salient differences have been noted between the faunas of the various exposures. The fauna is rich, and at Bendigo is usually fairly well preserved, though the beds are often indurated and much cleaved. Many new species are as yet undiagnosed, and several of the old records of *Didymograptus* (*sensu stricto*) are probably incorrect. I have not seen any Diplograptidæ from the rocks of this series, though two species have been recorded from Bendigo. As the family is represented in younger rocks a few miles to the north of the town, in what is known as the Whipstick Country, it is probable that they came from there, the term Bendigo having been used in a loose geographical way. In any case the specific record is open to doubt.

The following species occur, amongst others: *Didymograptus bifidus*, J. Hall; *D. gracilis*, Tqt.; *D.* cf. *decens*, Tqt.; *D. caduceus*, Salter; *Tetragraptus fruticosus*, J. Hall; *T. serra*, Brong.; *T. quadribrachiatus*, J. Hall; *Dichograptus octobrachiatus*, J. Hall; *Phyllograptus typus*, J. Hall; *Goniograptus Thureaui*, McCoy; *G. macer*, n.sp. (vide infra).

A mere inspection of the list hardly brings out the character of the fauna, as a good deal depends on the relative abundance of certain forms. *Tetragraptus fruticosus* and *Phyllograptus typus* are very abundant, while *Didymograptus bifidus* is very rare and perhaps indicative of the higher beds of the series. *Didymograptus caduceus*, again, is rare and small, and it is interesting to notice, as we pass up through a long series of rocks above those of Bendigo, that it increases in relative numbers, and at the same time gradually attains a much larger size, till it reaches its maximum near the horizon of the uppermost Castlemaine beds, where it crowds the rocks to the almost entire exclusion of other forms. It then enters on the period of its decline, is but sparingly represented by stunted forms at Darriwill, and perhaps ranges up into the Upper Ordovician.

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[1] Proc. Roy. Soc. Victoria, new ser., vol. xi, 1898 (1899), pp. 164–178, pls. xvii, xviii, xix.

3. *Castlemaine Series.*—The rocks which form this series overlie the Bendigo beds conformably. The change in fauna is slight, but *Tetragraptus fruticosus*, so characteristic of the older beds, is absent, and *Didymograptus bifidus* becomes abundant at the base of the Castlemaine rocks. I have subdivided the rocks into several minor zones,[1] but need not here consider the details. The summit of the series has not been clearly marked off from the beds which succeed it, as they are not known to come into contact.

In the lowermost beds *Didymograptus bifidus*, J. Hall, as just stated, is abundant, but soon disappears. *Phyllograptus typus* long persists, and is survived for a short time by *P. angustifolius*, J. Hall. Species of *Diplograptus* appear in the higher beds, but not, apparently, in the lower. A species of *Clonograptus* occurs in the lower beds, but soon disappears. *Loganograptus Logani* puts in an appearance in the highest zones and ranges up into the Darriwill Series.

Though the position of *Didymograptus bifidus* and its allies would appear to be somewhat lower, relatively, than what it is in the Northern Hemisphere, yet if it be true, as has been suggested by Nicholson and Marr, that the 'tuning-fork' group is phylogenetically connected with *Tetragraptus fruticosus*, then its position in beds so closely associated with those in which the latter species occurs is no more than we should reasonably expect to find. The really striking point is that it should die out so soon with us, and characterize rocks that are closely connected by their fauna with the Lower Arenig and not with the Upper. Although we seem to be able to trace the descent in a general way of the 'tuning-fork' group from the *Tetragraptus fruticosus* group, still we are unable, I venture to think, to descend from generals to particulars.

The late appearance of *Loganograptus* is of interest. As it is one of the species figured by McCoy in his "Prodromus of the Palæontology of Victoria," and was stated to occur commonly at Castlemaine, I was naturally on the look out for it, and for a long time in vain. I found it at last about a mile to the south of the town, where I made a prolonged search for it, on the strike of McCoy's locality, which is in the centre of the town and inaccessible. It is never associated with *Phyllograptus typus*, which does not range as high as the beds in which *Loganograptus* first appears. *Dichograptus octobrachiatus* has also disappeared, after having long persisted, while the commonest associate is *Didymograptus caduceus*, which is represented by the large variety characteristic of the higher beds of the Castlemaine Series. In Canada the only species given by Ami[1] as associated with it are *Rouvilligraptus Richardsoni* and *Goniograptus Thureani*. The former species has not been recognized in Australia, while the latter is confined to a lower horizon, not passing up into the Castlemaine Series. In the Skiddaw Slates it would also appear that the position of *Loganograptus* is lower in the series, for Miss G. L. Elles,[2] in her table of suggested phylogeny, puts down *Dichograptus octobrachiatus* and *Tetragraptus quadribrachiatus* as derived from *Loganograptus Logani*. Genealogical trees are notoriously difficult to draw up in biology where there is great danger of confusing the different collateral branches. The question suggests itself as to what is the real order of the appearance of these forms. Migration, one would think, must produce apparent inversions in widely separated regions, and it will be evident that several such inversions actually do occur in the case of our graptolites, or, in other words, that we find in Victoria forms associated which are not found together in the Northern Hemisphere, and *vice versâ*. That the general phylogeny of the graptolites may be traced out on the lines indicated by Nicholson and Marr,[3] and so ably elaborated by Miss Elles, there can be but little question, but the task of elaborating the details is complicated when we take into consideration the possibility that the succession of life in any particular set of beds may not be the true one. The general succession of the graptolites in Australia and the Northern Hemisphere is the same, but there are undoubtedly differences in details.

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[1] Proc. Roy. Soc. Victoria, new ser., vol. vii (1894), pp. 55-88.

The Castlemaine Series has been best studied in the district whence its name is taken, and it there includes, as far as I have seen, all the beds above the Bendigo Series, which is but slightly exposed on the main anticline which passes through Chewton.

The group includes rocks occurring at Castlemaine, a large area in the Bacchus Marsh and Coimaidai Districts,[4] Gisborne, and perhaps a considerable part of the intervening country, as well as an area in the Whipstick, north of Bendigo.

The fauna includes *Didymograptus bifidus*, J. Hall; *D. Murchisoni*, Beck; *D.* cf. *decens*, Tqt.; *D. extensus*, J. Hall; *D. caduceus*, Salter; *Tetragraptus serra*, J. Hall; *T. quadribrachiatus*, J. Hall; *T. proiectus*, n.sp. (v. infra); *Dichograptus octobrachiatus*, J. Hall; *D. octonarius*, J. Hall; *Clonograptus*, sp.: *Phyllograptus typus*, J. Hall; *P. angustifolius*, J. Hall; *Loganograptus Logani*, J. Hall; *Goniograptus macer*, n.sp. (v. infra); *Dendrograptus*, sp.; *Diplograptus*, spp.; *Climacograptus*, sp.; and perhaps *Trigonograptus*, as well as many forms as yet unidentified.

4. *Darriwill Series.*—The only locality at which these rocks are known is in the parish of Darriwill, where graptolites were found by

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[1] Geol. and Nat. Hist. Surv. Canada, new ser., Ann. Rep., vol. iii, pt. 2, K, p. 116.

[2] Q.J.G.S., vol. liv (1898), p. 537.

[3] Geol. Mag., 1895, pp. 529–539.

[4] Proc. Roy. Soc. Victoria, new ser., vol. x, 1897 (1898), pp. 202-3.

Wilkinson in 1864. The fauna differs from the typical Castlemaine one by the almost entire absence of *Didymograptus caduceus*, and the appearance of *Lasiograptus* and *Glossograptus*. *Trigonograptus* and several species of *Didymograptus* and *Climacograptus* occur, while *Tetragraptus serra* and *Loganograptus* still persist. Sir F. McCoy records *Tetragraptus Headi*, but judging by the figure and description I am inclined to doubt the identification.

The beds are very rich, and many new forms are present, but the rocks at the only fossiliferous localities known are so much weathered that further elucidation of the fauna is rendered difficult.

This series appears to mark the close of the Lower Ordovician, as in the succeeding rocks Dicranograptidæ put in an appearance.

Upper Ordovician.

No stratigraphical work has yet been done in the Upper Ordovician beds, so that in the present state of our knowledge it will be unwise to attempt any correlation based on the occurrence of a few stray forms the vertical range of which we cannot positively state.

Rocks rich in graptolites, but in a very bad state of preservation, occur on the Saltwater River about twenty miles north of Melbourne. There are present *Cœnograptus gracilis*, apparently, as well as *Dicranograptus ramosus* and several species of *Dicellograptus* and of Diplograptidæ.

A somewhat similar fauna has recently been found near Matlock on the Woods' Point Road,[1] whence I have identified *Diplograptus foliaceus*, Murch., and perhaps *Dicellograptus Morrisii*, Hopk. Diplograptidæ are also represented. The rocks of this area have long been considered Silurian from the occurrence of *Cardium Gippslandicum*, McCoy, the only fossil known from the district. Elsewhere this *Cardium* is associated with an *Orthoceras*, identified by McCoy as *O. striatopunctatum*, Münst., and so considered by him to be of Silurian age. As the age of the graptolites is Ordovician beyond a doubt, the fact of the occurrence of Silurian rocks in the neighbourhood may be questioned till better evidence is forthcoming, though of course the Ordovician may be a small inlier.

The age of the rocks in North-Eastern Victoria was long in doubt, but the discovery by Mr. Ferguson[2] of what proved to be Upper Ordovician graptolites at three widely separated localities showed that a great part of the area must be occupied by rocks of that age. I have identified *Dicellograptus elegans*, Carr., and *Climacograptus bicornis*, J. Hall, from Wombat Creek, where Diplograptidæ are also represented. At Tungamah we get *Diplograptus pristis*, His., and perhaps *Dicellograptus sextans* and *Dicellograptus ramosus*, all, however, badly preserved. From Walwa Creek come *Dicellograptus anceps*, Nich.; *Diplograptus pristis*, His.; *D. truncatus*, Lapw.; *Climacograptus bicornis*, J. Hall. From Eastern Gippsland a few forms, also belonging to the Upper

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[1] Proc. Roy. Soc. Victoria, new ser., vol. x (1897), pp. 13–15.

[2] Id., vol. x, 1896 (1897), pp. 183–6.

Ordovician, have been doubtfully recorded,[1] the condition of the specimens rendering specific identification impossible, though I consider the generic character of the fossils sufficiently clear.

Silurian.

The Saltwater River, in its course south from the Dividing Range, passes over the boundary between the Ordovician and Silurian formations. The river-valley is cut deeply through the great basaltic plain of Western Victoria, which here reaches almost its eastern limit. As is usual in such gorges, the basaltic detritus deeply masks the hill-sides, and outcrops of older rocks are isolated and small, so that whether the junction is conformable or not has not been settled. The question has been avoided on our geological maps by colouring Ordovician to the border of one sheet and beginning the next with Silurian. In the north-east of the colony, however, at Wombat Creek, there is, according to Mr. W. H. Ferguson, of the Department of Mines, an unconformable junction with a conglomerate at the base of the Silurian. The graptolites from the lower beds which he obtained, and which were submitted to me by the Department, are, as mentioned above, of Ordovician age. The fossils from the upper series over the conglomerate were sent to Mr. R. Etheridge, jun. They were in a very imperfect state, but from an examination of them Mr. Etheridge says[2] that he is "inclined to regard the specimens . . . . as of Upper Silurian age," Upper Silurian being used in the sense in which Silurian is used in this paper. There would appear from this, then, that there is a physical unconformity between the two formations in Victoria. That an unconformity exists was long ago asserted by Dr. Selwyn,[3] the statement being based on the difference in the average amount of dip in the two formations, and not on any observed contact. Mr. R. A. F. Murray, lately Government Geologist of the Colony, says that "the precise lines of junction of the two groups have not yet been so nearly ascertained as to enable it to be stated that they are stratigraphically unconformable."[4] Mr. Ferguson's observations, however, would seem to settle the point.

As previously mentioned, the earliest known graptolite locality in Australia lies near the township of Keilor, where Aplin found specimens in 1855. There are one or two species of Monograptidæ present, none of which I find well enough preserved for description, and *Diplograptus* is possibly represented. About a mile from the locality just mentioned another outcrop occurs, which contains a few examples of *Monograptus*, but which is chiefly noticeable as being the spot where *Retiolites Australis*, McCoy, is found, and which has not hitherto been found elsewhere.

The records from other localities are not very satisfactory. I have identified *Monograptus priodon*, from Macclesfield, and *M.* cf. *dubius*,

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[1] Geol. Surv. Victoria, Prog. Rep., vol. ix (1898), pp. 126–8.

[2] Ibid., p. 126.

[3] Intercolonial Exhibition Essays, Melbourne, 1867, p. 12.

[4] "Geology and Physical Geography of Victoria," p. 43.

Suess, from South Yarra, while a few other badly preserved examples of *Monograptus* have also been found at this last locality. From Alexandra a large number of specimens of the same genus have been obtained, all apparently of the one species, but all so badly preserved that no useful purpose would be served by either recording them as old species or describing them as new. It is worthy of remark, however, that no sign of Diplograptidæ has been found at this locality, so that we may perhaps assume that the beds are not very near the base of the formation.

The record, then, of Silurian forms is meagre in the extreme, for we can do little more than assert their presence in the formation, and must await the advent of better material before reliable definite statements can be made.

The absence of many characteristic genera, both Ordovician and Silurian, from our records must be regarded as apparent rather than real. The Lower Ordovician beds are the only ones that have been examined in any detail, while the Upper Ordovician rocks, hitherto worked, are either badly jointed mudstones or highly indurated slates, in which graptolites merely appear as a glaze on the surface.

Other Australasian Localities.

With regard to other Australasian graptolites the information is as yet meagre.

Tasmania has apparently yielded a single specimen, which was identified as *Diplograptus nodosus*.[1] I have elsewhere[2] given reason for supposing that a *Diplograptus* was found, and for the worthlessness of the specific identification, and for the correlation with Victorian beds founded upon it.

New South Wales has recently afforded some Upper Ordovician forms as recorded by Mr. W. S. Dun.[3] Dicranograptidæ and Diplograptidæ are common, but badly preserved. *Phyllograptus* is doubtfully recorded from the same beds, and Mr. Dun kindly showed me the specimen, which, however, I am inclined to regard as one of the Retiolitidæ. *Phyllograptus* certainly does not range as high. These forms come from the south-east corner of the colony, but similar forms have since then been found as far north as the latitude of Sydney, and throw considerable light on the age of a series of slates and sandstones hitherto tentatively regarded as Silurian.

In New Zealand Lower Ordovician graptolites occur, and Sir James Hector[4] gives a few rough woodcuts of some of the forms, but does not identify any of the species. Frech[5] gives a few records, which are all of Lower Ordovician forms, and I have examples of *Didymograptus bifidus* from Nelson.

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[1] Thureau, "Report on the . . . Lisle Goldfield": Tasmanian House of Assembly Journal, vol. xliii (1882), No. 146.

[2] Rep. Aust. Ass. Adv. Science, Sydney, 1898, p. 401.

[3] Records Geol. Surv. New South Wales, vol. v (1897), p. 124.

[4] Cat. N.Z. Geol. Exhibits, Ind. and Col. Exhib., 1886, p. 82.

[5] Lethæa Palæozoica, Bd. i (1897).

REMARKS ON SOME OF THE FORMS, WITH DESCRIPTIONS OF NEW SPECIES.

Monograptus, sp. (Pl. XXII, Fig. 1.)

The specimen figured shows the characters of the genus, but is too imperfect for specific description, and the figure is merely given as evidence of the occurrence of the genus in our beds.

Locality. — Keilor, from the locality where Aplin first found graptolites.

Didymograptus gracilis, Törnquist. (Pl. XXII, Fig. 2.)

Acta Univ. Lund, vol. xxvi, pt. 2, iv, p. 17, pl. i, figs. 9–12.

Hydrosome slender. Sicula about 1·3 mm. long and very narrow, with a very delicate virgula, which is traceable for about 0·7 mm. Branches extending at 180° and apparently arising at very different levels from the sicula, the left side of which projects as an acute tooth. The left branch is given off from about its middle, the right branch appearing to rise at the level of the aperture. Dorsal edge of the branches convexly swollen opposite the middle of each theca. Thecæ about seven in 10 mm.; slender; outer edge slightly concave, apertural edge straight and facing somewhat inwards, the two edges forming an acute denticle.

Törnquist says that he had an example showing the hair-like virgula, but that he was subsequently unable to find it.[1] It is clearly visible in the figured specimen. Breadth of branch about 0 3 mm.; width of thecæ at aperture about the same.

Locality.—Bendigo; exact locality unknown.

Leptograptus antiquus, T. S. Hall. (Pl. XXII, Figs. 3, 4.)

Locality.—Lancefield.

Tetragraptus projectus, n.sp. (Pl. XXII, Figs. 5, 6.)

Primaries in a straight line, about 1 mm. long. Secondaries diverging at an angle of 90° from each other, rigid, narrow, about 1·5 mm. broad, and may be more than 6 cm. long. Central disc oblong, with straight sides, slightly curving outwards at the angles to embrace the secondary branches. Length parallel to the direction of the primary branches, 7 mm.; breadth, 5 mm. Sicula not visible. Thecæ eight in 1 cm.; short; slightly expanding; apertural margin slightly concave, forming an angle of about 105°; outer margin concave, inclined at 50° to 55°. Amount of overlap not clearly shown in the only specimen found, and cannot be traced further than is shown in the enlarged figure (6).

The narrowness of the secondary branches and the prominent thecæ distinguish the species from all others to which I can find reference.

Locality.—A single specimen, both sides preserved, from the slate quarries five miles west of Gisborne, associated with the large form of *Didymograptus caduceus*, *Tetragraptus serra*, *Diplograptus*, sp., *Climacograptus*, sp., and apparently *Phyllograptus typus*.

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[1] Loc. cit., p. 17, footnote.

Dichograptus octonarius. J. Hall. (Pl. XXII, Fig. 7.)

The tertiary branches at a little more than 1 cm. from the sicula are from 2·5 to 3 mm. broad. Thecæ eleven in 1 cm., slightly expanding, curved, inclined at about 30° in the middle part of their length, and at nearly twice that angle near their aperture. Apertural margin strongly concave, forming an angle of about 150°, and making with the outer margin a prominent denticle. The species seems somewhat more lax in habit than *D. octobrachiatus*, and specimens are common in the middle beds of the Castlemaine district, which lie in very similar positions to that figured by Hall in his "Graptolites of the Quebec Group."

Locality.—The figured specimen is from Victoria Gully, Castlemaine.

Clonograptus rigidus, J. Hall, var. *tenellus*, Lns. (Pl. XXII, Fig. 8.)

The figured specimen shows a common form in the Lancefield beds, where it is associated with the typical form, as described by Hall. *C. rigidus* and *C. tenellus* cannot, I think, be separated, and the extremes are connected by a long intermediate series at Lancefield.

Goniograptus macer, n.sp. (Illustration, p. 450, Figs. 9, 10.)

SYN. *Loganograptus Logani*? R. Etheridge, jun. (*non* J. Hall): Ann. Mag. Nat. Hist., 1874, p. 4, pl. iii, fig. 12.

Id., McCoy (*non* J. Hall): Prod. Pal. Victoria, Dec. i, p. 19 (loc. B *b*, 29, specimens in the National Museum, Melbourne).

Goniograptus, sp., T. S. Hall: Proc. Roy. Soc. Victoria, N.S., vol. vii, 1894 (1895), p. 72.

Hydrosome slender. Primary branches about 1 mm. in length, and forming an angle of 180° with each other. Secondary branches diverging at about 90° from each other, and then bending in a zigzag manner at intervals of about 1·5 mm., and giving off tertiary branches from the salient angle. Tertiary branches form two to four in number. After giving off the final tertiary branches the secondary branches as well as the tertiaries may reach the length of 30 or 40 mm., and are fairly rigid. Sicula about 1 mm. in length, slender, and very slowly tapering. Thecæ eight or nine in 10 mm., overlapping by half their length. Apertural margin slightly concave, forming an angle of about 110° with the axis of the branch. Outer margin inclined at about 25° to the axis of the branch, gently curving towards the distal extremity.

Though the species is fairly common, the delicate nature of the hydrosome rarely allows of its being found in a well-preserved condition, and the thecæ are usually invisible in specimens in slate.

Under the name of *Goniograptus*, sp., I have previously dealt with this species, and shown that it has been confounded with *Loganograptus*, which occurs only in higher beds, the two forms never being associated. The species is evidently congeneric with *Dichograptus Kjerulfi*, Herrmann.[1]

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[1] See GEOL. MAG., 1886, pp. 13 et seq.

In the above description I have regarded the secondary branches as giving off tertiaries on alternate sides, instead of treating it as a case of dichotomy, that is, I look at it as showing what botanists term sympodial branching. In this I follow the view of McCoy in his description of the type species, *Goniograptus Thureaui*. In a simple species, such as the present, the distinction may appear trivial, but in the type species, and still more so in an undescribed member of the genus in the National Museum, Melbourne, simplicity is certainly gained by this manner of considering the branching. A similar mode of branching occurs, of course, in *Thamnograptus*.

Locality and Horizon.—It occurs throughout the Bendigo and in the lower members of the Castlemaine Series. In the former it is associated with the stouter and much more copiously branched *G. Thureaui*, which is confined to these beds.

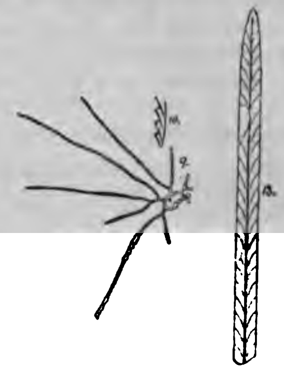


FIG. 9.—*Goniograptus macer*, n.sp.
,, 10.—The same, thecæ enlarged.
,, 13.—*Trigonograptus Wilkinsoni*, n.sp.
(Reduced to one-fourth nat. size.)

Bryograptus Victoriæ, T. S. Hall. (Pl. XXII, Figs. 11, 12.)

This species is fairly common at Lancefield, and indistinct specimens, with more branches developed than I have figured, occur, but I have shown a well-preserved form. It occurs on the same slabs with the *Leptograptus* figured above, as well as with most, if not all, of the species recorded from that locality in this paper.

Trigonograptus Wilkinsoni, n.sp. (Illustration supra, Fig. 13.)

Hydrosome straight, parallel-sided, gently curving to a blunt point at the distal end. Thecæ inclined at about 30°, gently curving outwards to the margin of the polypary, which they do not indent; about six and a half in 10 mm., opposite to one another. Virgula very distinct, straight, not traceable quite to the distal extremity. Breadth of hydrosome nearly 3 mm., greatest observed length (broken) 4 cm.

The species seems very distinct from those already described by the small number of thecæ in a given length. In general form it approaches closely to Hall's figures of *T. ensiformis*, but the thecæ are opposite, and not alternate, and are gently curved. One specimen shows the proximal, or sicular end, to be more abruptly rounded than the distal.

Locality.—Sutherland's Creek, Darriwill, close to the spot marked "W.L.S.I." on Wilkinson's map.

DESCRIPTION OF PLATE XXII.

Fig. 1.—*Monograptus*, sp., enlarged.
,, 2.—*Didymograptus gracilis*, Tqt., enlarged.
,, 3.—*Leptograptus antiquus*, T. S. Hall.
,, 4.—The same, showing thecæ enlarged.
,, 5.—*Tetragraptus projectus*, n.sp.
,, 6.—The same, showing thecæ enlarged.
,, 7.—*Dichograptus octonarius*, J. Hall; thecæ enlarged.
,, 8.—*Clonograptus rigidus*, J. Hall, var. *tenellus*, Lns.
,, 11.—*Bryograptus Victoriæ*, T. S. Hall.
,, 12.—The same, enlarged.

(Unless otherwise stated, the figures are of the natural size.)

III.—On a New Species of *Lepracanthus* from the Yorkshire Coal-measures.

By Edgar D. Wellburn, L.R.C.P. & S.E., F.R.I.P.H., F.G.S., etc.

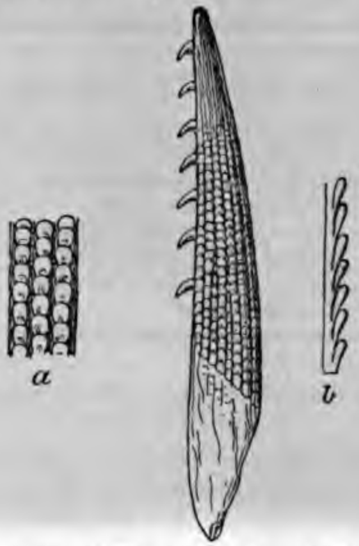
Genus Lepracanthus, Owen.

Geol. Mag., Dec. I, Vol. VI (1869), p. 481.

Lepracanthus rectus, sp. nov.

The spine is 40 mm. in length, by 5 mm. in width at the junction of the inserted and exserted portions; from this point the spine gradually narrows to a moderately fine point at the apex. The posterior margin is nearly straight, the anterior one gently curved, the curve being more marked distally. The lateral surfaces meet in front at a moderately acute angle, the spine being much laterally compressed. The posterior surface is concave, and each margin is armed with the usual well-marked recurved denticles. The sides of the exserted portion are ornamented with a longitudinal series of ganoine-coated, tuberculated ridges. The tubercles are squarely shaped, and are arranged in a close series, even in the proximal portion of the spine. In the distal two-thirds there are five such ridges, but in the proximal third they are increased by intercalation to seven. Their direction is as follows:—The anterior one forms a prominent keel on the anterior border, the next two run to the tip more or less parallel to that border, one runs close to and parallel with the posterior border, another runs to the apex between these two sets, and, lastly, on each side of this ridge are intercalated two shorter ones. The inserted portion is well marked, and the line of demarcation between this and the exserted portion runs upwards and backwards, cutting the anterior and posterior margins at an angle of 45 degrees.

The present spine, for which I propose the specific name *rectus*, differs from *L. Colei*, Owen, in that it is straighter and more robust, in the ridges being increased proximally by intercalation, and in the tubercles being squarely shaped and arranged in a close series, even in the proximal portion of the spine.



Lepracanthus rectus, sp. nov.—(*a*) Three ridges enlarged to show the ornamentation. (*b*) Ridge seen from the lateral aspect.

TYPE.—Author's collection.

FORM. AND LOC.—Shale above the Better Bed Coal, Lower Coal-measures, Low Moor, Yorks.

Both Dr. Traquair and Mr. A. Smith Woodward have seen the spine, and agree with me as to its specific distinction.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. DOVER, 1899.

ADDRESS TO THE GEOLOGICAL SECTION, BY SIR ARCHIBALD GEIKIE, D.C.L., D.Sc., F.R.S., President of the Section.

AMONG the many questions of great theoretical importance which have engaged the attention of geologists, none has in late years awakened more interest or aroused livelier controversy than that which deals with Time as an element in geological history. The various schools which have successively arisen—Cataclysmal, Uniformitarian, and Evolutionist—have had each its own views as to the duration of their chronology, as well as to the operations of terrestrial energy. But though holding different opinions, they did not make these differences matter of special controversy among hemselves. About thirty years ago, however, they were startled y a bold irruption into their camp from the side of physics. They vere then called on to reform their ways, which were declared to be latly opposed to the teachings of natural philosophy. Since that eriod the discussion then started regarding the age of the Earth nd the value of geological time has continued with varying nimation. Evidence of the most multifarious kind has been rought forward, and arguments of widely different degrees of alidity have been pressed into service both by geologists and alæontologists on one side and by physicists on the other. For he last year or two there has been a pause in the controversy, though no general agreement has been arrived at in regard to the matters in dispute. The present interval of comparative quietude seems favourable for a dispassionate review of the debate. I propose, therefore, to take, as perhaps a not inappropriate subject on which to address geologists upon a somewhat international occasion like this present meeting of the British Association at Dover, the question of Geological Time. In offering a brief history of the discussion, I gladly avail myself of the opportunity of enforcing one of the lessons which the discussion has impressed upon my own mind, and to point a moral which, as it seems to me, we geologists may take home to ourselves from a consideration of the whole question. There is, I think, a practical outcome which may be made to issue from the controversy in a combination of sympathy and co-operation among geologists all over the world. A lasting service will be rendered to our science if by well-concerted effort we can place geological dynamics and geological chronology on a broader and firmer basis of actual experiment and measurement than has yet been laid.

To understand aright the origin and progress of the dispute regarding the value of time in geological speculation, we must take note of the attitude maintained towards this subject by some of the early fathers of the science. Among these pioneers none has left his mark more deeply graven on the foundations of modern geology than James Hutton. To him, more than to any other writer of his day, do we owe the doctrine of the high antiquity of our globe. No one before him had ever seen so clearly the abundant and impressive proofs of this remote antiquity recorded in the rocks of the earth's crust. In these rocks he traced the operation of the same slow and quiet processes which he observed to be at work at present in gradually transforming the face of the existing continents. When he stood face to face with the proofs of decay among the mountains, there seems to have arisen uppermost in his mind the thought of the immense succession of ages which these proofs revealed to him. His observant eye enabled him to see "the operations of the surface wasting the solid body of the globe, and to read the unmeasurable course of time that must have flowed during those amazing operations, which the vulgar do not see, and which the learned seem to see without wonder."[1] In contemplating the stupendous results achieved by such apparently feeble forces, Hutton felt that one great objection he had to contend with in the reception of his theory, even by the scientific men of his day, lay in the inability or unwillingness of the human mind to admit such large demands as he made on the past. "What more can we require?" he asks in summing up his conclusions; and he answers the question in these memorable words: "What more can we require? Nothing but time. It is not any part of the process that will be disputed; but after allowing all the parts, the whole will be denied; and for what?—only because we are not disposed to allow that quantity of time which the ablution of so much wasted mountain might require."[1]

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[1] "Theory of the Earth," vol. i, p. 108.

Far as Hutton could follow the succession of events registered in the rocky crust of the globe, he found himself baffled by the closing in around him of that dark abysm of time into which neither eye nor imagination seemed able to penetrate. He well knew that, behind and beyond the ages recorded in the oldest of the primitive rocks, there must have stretched a vast earlier time, of which no record met his view. He did not attempt to speculate beyond the limits of his evidence. "I do not pretend," he said, "to describe the beginning of things; I take things such as I find them at present, and from these I reason with regard to that which must have been."[2] In vain could he look, even among the oldest formations, for any sign of the infancy of the planet. He could only detect a repeated series of similar revolutions, the oldest of which was assuredly not the first in the terrestrial history, and he concluded, as "the result of this physical inquiry, that we find no vestige of a beginning, no prospect of an end."[3]

This conclusion from strictly geological evidence has been impugned from the side of physics, and, as further developed by Playfair, has been declared to be contradicted by the principles of natural philosophy. But if it be considered on the basis of the evidence on which it was originally propounded, it was absolutely true in Hutton's time and remains true to-day. That able reasoner never claimed that the earth has existed from all eternity, or that it will go on existing for ever. He admitted that it must have had a beginning, but he had been unable to find any vestige of that beginning in the structure of the planet itself. And notwithstanding all the multiplied researches of the century that has passed since the immortal "Theory of the Earth" was published, no relic of the first condition of our earth has been found. We have speculated much, indeed, on the subject, and our friends the physicists have speculated still more. Some of the speculations do not seem to me more philosophical than many of those of the older cosmogonists. As far as reliable evidence can be drawn from the rocks of the globe itself, we do not seem to be nearer the discovery of the beginning than Hutton was. The most ancient rocks that can be reached are demonstrably not the first-formed of all. They were preceded by others which we know must have existed, though no vestige of them may remain.

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[1] "Theory of the Earth," vol. ii, p. 329.

[2] Op. cit., vol i, p. 173, note.

[3] Op. cit., vol. i, p. 200.

It may be further asserted that, while it was Hutton who first impressed on modern geology the conviction that for the adequate comprehension of the past history of the earth vast periods of time must be admitted to have elapsed, our debt of obligation to him is increased by the genius with which he linked the passage of these vast periods with the present economy of nature. He first realized the influence of time as a factor in geological dynamics, and first taught the efficacy of the quiet and unobtrusive forces of nature. His predecessors and contemporaries were never tired of invoking the more vigorous manifestations of terrestrial energy. They saw in the composition of the land and in the structure of mountains and valleys memorials of numberless convulsions and cataclysms. In Hutton's philosophy, however, "it is the little causes, long continued, which are considered as bringing about the greatest changes of the earth."[1]

And yet, unlike many of those who derived their inspiration from his teaching, but pushed his tenets to extremes which he doubtless never anticipated, he did not look upon time as a kind of scientific fetich, the invocation of which would endow with efficacy even the most trifling phenomena. As if he had foreseen the use that might be made of his doctrine, he uttered this remarkable warning: "With regard to the effect of time, though the continuance of time may do much in those operations which are extremely slow, where no change, to our observation, had appeared to take place, yet, where it is not in the nature of things to produce the change in question, the unlimited course of time would be no more effectual than the moment by which we measure events in our observations."[2]

We thus see that in the philosophy of Hutton, out of which so much of modern geology has been developed, the vastness of the antiquity of the globe was deduced from the structure of the terrestrial crust and the slow rate of action of the forces by which the surface of the crust is observed to be modified. But no attempt was made by him to measure that antiquity by any of the chronological standards of human contrivance. He was content to realize for himself and to impress upon others that the history of the earth could not be understood, save by the admission that it occupied prolonged though indeterminate ages in its accomplishment. And assuredly no part of his teaching has been more amply sustained by the subsequent progress of research.

Playfair, from whose admirable "Illustrations of the Huttonian Theory" most geologists have derived all that they know directly of that theory, went a little further than his friend and master in dealing with the age of the earth. Not restricting himself, as Hutton did, to the testimony of the rocks, which showed neither vestige of a beginning nor prospect of an end, he called in the evidence of the cosmos outside the limits of our planet, and declared that in the firmament also no mark could be discovered of the commencement or termination of the present order, no symptom of infancy or old age, nor any sign by which the future or past duration of the universe might be estimated.[1] He thus advanced beyond the strictly geological bases of reasoning, and committed himself to statements which, like some made also by Hutton, seem to have been suggested by certain deductions of the French mathematicians of his day regarding the stability of the planetary motions. His statements have been disproved by modern physics; distinct evidence, both from the earth and the cosmos, has been brought forward of progress from a beginning which can be conceived, through successive stages to an end which can be foreseen. But the disproof leaves Hutton's doctrine about the vastness of geological time exactly where it was. Surely it was no abuse of language to speak of periods as being vast which can only be expressed in millions of years.

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[1] "Theory of the Earth," vol. ii, p. 205.

[2] Op. cit., vol. i, p. 44.

It is easy to understand how the Uniformitarian school, which sprang from the teaching of Hutton and Playfair, came to believe that the whole of eternity was at the disposal of geologists. In popular estimation, as the ancient science of astronomy was that of infinite distance, so the modern study of geology was the science of infinite time. It must be frankly conceded that geologists, believing themselves unfettered by any limits to their chronology, made ample use of their imagined liberty. Many of them, following the lead of Lyell, to whose writings in other respects modern geology owes so deep a debt of gratitude, became utterly reckless in their demands for time, demands which even the requirements of their own science, if they had adequately realized them, did not warrant. The older geologists had not attempted to express their vast periods in terms of years. The indefiniteness of their language fitly denoted the absence of any ascertainable limits to the successive ages with which they had to deal. And until some evidence should be discovered whereby these limits might be fixed and measured by human standards, no reproach could justly be brought against the geological terminology. It was far more philosophical to be content, in the meanwhile, with indeterminate expressions, than from data of the weakest or most speculative kind to attempt to measure geological periods by a chronology of years or centuries.

In the year 1862 a wholly new light was thrown on the question of the age of our globe and the duration of geological time by the remarkable paper on the Secular Cooling of the Earth communicated by Lord Kelvin (then Sir William Thomson) to the Royal Society of Edinburgh.[2] In this memoir he first developed his now well-known argument from the observed rate of increase of temperature downwards from the surface of the land. He astonished geologists by announcing to them that some definite limits to the age of our planet might be ascertained, and by declaring his belief that this age must be more than 20 millions, but less than 400 millions of years.

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[1] "Illustrations of the Huttonian Theory," § 118.

[2] Trans. Roy. Soc. Edin., vol. xxiii (1862).

Nearly four years later he emphasized his dissent from what he considered to be the current geological opinions of the day by repeating the same argument in a more pointedly antagonistic form in a paper of only a few sentences, entitled "The Doctrine of Uniformity in Geology briefly refuted."[1]

Again, after a further lapse of about two years, when, as President of the Geological Society of Glasgow, it became his duty to give an address, he returned to the same topic and arraigned more boldly and explicitly than ever the geology of the time. He then declared that "a great reform in geological speculation seems now to have become necessary," and he went so far as to affirm that "it is quite certain that a great mistake has been made—that British popular geology at the present time is in direct opposition to the principles of natural philosophy."[2] In pressing once more the original argument derived from the downward increase of terrestrial temperature, he now reinforced it by two further arguments, the one based on the retardation of the earth's angular velocity by tidal friction, the other on the limitation of the age of the sun.

These three lines of attack remain still those along which the assault from physics is delivered against the strongholds of geology. Lord Kelvin has repeatedly returned to the charge since 1868, his latest contribution to the controversy having been pronounced two years ago.[3] While his physical arguments remain the same, the limits of time which he deduces from them have been successively diminished. The original maximum of 400 millions of years has now been restricted by him to not much more than 20 millions, while Professor Tait grudgingly allows something less than 10 millions.[4]

Soon after the appearance of Lord Kelvin's indictment of modern geology in 1868, the defence of the science was taken up by Huxley, who happened at the time to be President of the Geological Society of London. In his own inimitably brilliant way, half seriously half playfully, this doughty combatant, with evident relish, tossed the physical arguments to and fro in the eyes of his geological brethren, as a barrister may flourish his brief before a sympathetic jury. He was willing to admit that "the rapidity of rotation of the earth *may* be diminishing, that the sun *may* be waxing dim, or that the earth itself *may* be cooling." But he went on to add his suspicion that "most of us are Gallios, 'who care for none of these things,' being of opinion that, true or fictitious, they have made no practical difference to the earth, during the period of which a record is preserved in stratified deposits."[5]

For the indifference which their advocate thus professed on their behalf most geologists believed that they had ample justification.

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[1] Proc. Roy. Soc. Edin., vol. v, p. 512 (Dec. 18, 1865).

[2] Trans. Geol. Soc. Glasgow, vol. iii, pp. 1, 16 (February, 1868).

[3] "The Age of the Earth," being the Annual Address to the Victoria Institute, June 2, 1897: Phil. Mag., January, 1899, p. 66.

[4] "Recent Advances in Physical Science," p 174.

[5] Presidential Address, Quart. Journ. Geol. Soc., 1869.

The limits within which the physicist would circumscribe the earth's history was so vague, yet so vast, that whether the time allowed were 400 millions or 100 millions of years did not seem to them greatly to matter. After all, it was not the time that chiefly interested them, but the grand succession of events which the time had witnessed. That succession had been established on observations so abundant and so precise that it could withstand attack from any quarter, and it had taken as firm and lasting a place among the solid achievements of science as could be claimed for any physical speculations whatsoever. Whether the time required for the transaction of this marvellous earth-history was some millions of years more or some millions of years less did not seem to the geologists to be a question on which their science stood in antagonism with the principles of natural philosophy, but one which the natural philosophers might be left to settle at their own good pleasure.

For myself, I may be permitted here to say that I have never shared this feeling of indifference and unconcern. As far back as the year 1868, only a month after Lord Kelvin's first presentation of his threefold argument in favour of limiting the age of the earth, I gave in my adhesion to the propriety of restricting the geological demands for time. I then showed that even the phenomena of denudation, which, from the time of Hutton downwards, had been most constantly and confidently appealed to in support of the inconceivably vast antiquity of our globe, might be accounted for, at the present rate of action, within such a period as 100 millions of years.[1] To my mind it has always seemed that whatever tends to give more precision to the chronology of the geologist, and helps him to a clearer conception of the antiquity with which he has to deal, ought to be welcomed by him as a valuable assistance in his inquiries. And I feel sure that this view of the matter has now become general among those engaged in geological research. Frank recognition is made of the influence which Lord Kelvin's persistent attacks have had upon our science. Geologists have been led by his criticisms to revise their chronology. They gratefully acknowledge that to him they owe the introduction of important new lines of investigation, which link the solution of the problems of geology with those of physics. They realize how much he has done to dissipate the former vague conceptions as to the duration of geological history, and even when they emphatically dissent from the greatly restricted bounds within which he would now limit that history, and when they declare their inability to perceive that any reform of their speculations in this subject is needful, or that their science has placed herself in opposition to the principles of physics, they none the less pay their sincere homage to one who has thrown over geology, as over so many other departments of natural knowledge, the clear light of a penetrating and original genius.

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[1] Trans. Geol. Soc. Glasgow, vol. iii, p. 189 (March 26, 1868). Sir W. Thomson acknowledged my adhesion in his reply to Huxley's criticism. Op. cit., p. 221.

When Lord Kelvin first developed his strictures on modern geology he expressed his opposition in the most uncompromising language. In the short paper to which reference has already been made, he announced, without hesitation or palliation, that he "briefly refuted" the doctrine of Uniformitarianism which had been espoused and illustrated by Lyell and a long list of the ablest geologists of the day. The severity of his judgment of British geology was not more marked than was his unqualified reliance on his own methods and results. This confident assurance of a distinguished physicist, together with a formidable array of mathematical formulæ, produced its effect on some geologists and palæontologists who were not Gallios. Thus, even after Huxley's brilliant defence, Darwin could not conceal the deep impression which Lord Kelvin's arguments had made on his mind. In one letter he wrote that the proposed limitation of geological time was one of his "sorest troubles." In another, he pronounced the physicist himself to be "an odious spectre."[1]

The same self-confidence of assertion on the part of some, at least, of the disputants on the physical side has continued all through the controversy. Yet when we examine the three great physical arguments in themselves, we find them to rest on assumptions which, though certified as "probable" or "very sure," are nevertheless admittedly assumptions. The conclusions to which these assumptions lead must depend for their validity on the degree of approximation to the truth in the premises which are postulated.

Now it is interesting to observe that neither the assumptions nor the conclusions drawn from them have commanded universal assent even among physicists themselves. If they were as self-evident as they have been claimed to be, they should at least receive the loyal support of all those whose function it is to pursue and extend the applications of physics. It will be remembered, however, that thirteen years ago Professor George Darwin, who has so often shown his inherited sympathy in geological investigation, devoted his presidential address before the Mathematical Section of this Association to a review of the three famous physical arguments respecting the age of the earth. He summed up his judgment of them in the following words:—"In considering these three arguments I have adduced some reasons against the validity of the first [tidal friction]; and have endeavoured to show that there are elements of uncertainty surrounding the second [secular cooling of the earth]; nevertheless they undoubtedly constitute a contribution of the first importance to physical geology. Whilst, then, we may protest against the precision with which Professor Tait seeks to deduce results from them, we are fully justified in following Sir William Thomson, who says that 'the existing state of things on the earth, life on the earth—all geological history showing continuity of life, must be limited within some such period of past time as 100,000,000 years.'"[2]

More recently Professor Perry has entered the lists, from the physical side, to challenge the validity of the conclusions so confidently put forward in limitation of the age of the earth. He has boldly impugned each of the three physical arguments. That which is based on tidal retardation, following Mr. Maxwell Close and Professor Darwin, he dismisses as fallacious. In regard to the argument from the secular cooling of the earth, he contends that it is perfectly allowable to assume a much higher conductivity for the interior of the globe, and that this assumption would vastly increase our estimate of the age of the planet. As to the conclusions drawn from the history of the sun, he maintains that, on the one hand, the sun may have been repeatedly fed by infalling meteorites, and that on the other the earth, during former ages, may have had its heat retained by a dense atmospheric envelope. He thinks that "almost anything is possible as to the present internal state of the earth," and he concludes in these words: "To sum up we can find no published record of any lower maximum age of life on the earth, as calculated by physicists, than 400 millions of years. From the three physical arguments, Lord Kelvin's higher limits are 1,000, 400, and 500 million years. I have shown that we have reasons for believing that the age, from all these, may be very considerably underestimated. It is to be observed that if we exclude everything but the arguments from mere physics, the *probable* age of life on the earth is much less than any of the above estimates; but if the palæontologists have good reasons for demanding much greater times, I see nothing from the physicist's point of view which denies them four times the greatest of these estimates."[1]

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[1] Darwin's Life and Letters, vol. iii, pp. 115, 146.

[2] Rep. Brit. Assoc., 1886, p. 517.

This remarkable admission from a recognized authority on the physical side re-echoes and emphasizes the warning pronounced by Professor Darwin in the address already quoted—"at present our knowledge of a definite limit to geological time has so little precision that we should do wrong to summarily reject any theories which appear to demand longer periods of time than those which now appear allowable."[2]

This 'wrong' which Professor Darwin so seriously deprecated has been committed not once, but again and again, in the history of this discussion. Lord Kelvin has never taken any notice of the strong body of evidence adduced by geologists and palæontologists in favour of a much longer antiquity than he is now disposed to allow for the age of the earth. His own three physical arguments have been successively restated, with such corrections and modifications as he has found to be necessary, and no doubt further alterations are in store for them. He has cut off slice after slice from the allowance of time which at first he was prepared to grant for the evolution of geological history, his latest pronouncement being that "it was more than twenty and less than forty million years, and probably much nearer twenty than forty."[3] But in none of his papers is there an admission that geology and palæontology, though they have again and again raised their voices in protest, have anything to say in the matter that is worthy of consideration.

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[1] Nature, vol. li, p. 585 (April 18, 1895).

[2] Rep. Brit. Assoc., 1886, p. 518.

[3] "The Age of the Earth," Presidential Address to the Victoria Institute for 1897, *p. 10*; also in Phil. Mag., January, 1899.

It is difficult satisfactorily to carry on a discussion in which your opponent entirely ignores your arguments, while you have given the fullest attention to his. In the present instance geologists have most carefully listened to all that has been brought forward from the physical side. Impressed by the force of the physical reasoning, they no longer believe that they can make any demands they may please on past time. They have been willing to accept Lord Kelvin's original estimate of 100 millions of years as the period within which the history of life upon the planet must be comprised; while some of them have even sought in various ways to reduce that sum nearer to his lower limit. Yet there is undoubtedly a prevalent misgiving, whether in thus seeking to reconcile their requirements with the demands of the physicist they are not tying themselves down within limits of time which on any theory of evolution would have been insufficient for the development of the animal and vegetable kingdoms.

It is unnecessary to recapitulate before this Section of the British Association, even in briefest outline, the reasoning of geologists and palæontologists which leads them to conclude that the history recorded in the crust of the earth must have required for its transaction a much vaster period of time than that to which the physicists would now restrict it.[1] Let me merely remark that the reasoning is essentially based on observations of the present rate of geological and biological changes upon the earth's surface. It is not, of course, maintained that this rate has never varied in the past. But it is the only rate with which we are familiar, which we can watch and in some degree measure, and which, therefore, we can take as a guide towards the comprehension and interpretation of the past history of our planet.

It may be, and has often been, said that the present scale of geological and biological processes cannot be accepted as a reliable measure for the past. Starting from the postulate, which no one will dispute, that the total sum of terrestrial energy was once greater than it is now and has been steadily declining, the physicists have boldly asserted that all kinds of geological action must have been more vigorous and rapid during bygone ages than they are to-day; that volcanoes were more gigantic, earthquakes more frequent and destructive, mountain upthrows more stupendous, tides and waves more powerful, and commotions of the atmosphere more violent, with more ruinous tempests and heavier rainfall. Assertions of this kind are temptingly plausible and are easily made. But it is not enough that they should be made; they ought to be supported by some kind of evidence to show that they are founded on actual fact and not on mere theoretical possibility. Such evidence, if it existed, could surely be produced. The chronicle of the earth's history, from a very early period down to the present time, has been legibly written within the sedimentary formations of the terrestrial crust. Let the appeal be made to that register. Does it lend any support to the affirmation that the geological processes are now feebler and slower than they used to be? If it does, the physicists, we might suppose, would gladly bring forward its evidence as irrefragable confirmation of the soundness of their contention. But the geologists have found no such confirmation. On the contrary, they have been unable to discover any indication that the rate of geological causation has ever, on the whole, greatly varied during the time which has elapsed since the deposition of the oldest stratified rocks. They do not assert that there has been no variation, that there have been no periods of greater activity, both hypogene and epigene. But they maintain that the demonstration of the existence of such periods has yet to be made. They most confidently affirm that whatever may have happened in the earliest ages, in the whole vast succession of sedimentary strata nothing yet has been detected which necessarily demands that more violent and rapid action which the physicists suppose to have been the order of nature during the past.

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[1] The geological arguments are briefly given in my Presidential Address to the British Association at the Edinburgh Meeting of 1892. The biological arguments were well stated, and in some detail, by Professor Poulton in his Address to the Zoological Section of the Association at the Liverpool Meeting of 1896.

So far as the potent effects of prolonged denudation permit us to judge, the latest mountain upheavals were at least as stupendous as any of older date whereof the basal relics can yet be detected. They seem, indeed, to have been still more gigantic than those. It may be doubted, for example, whether among the vestiges that remain of Mesozoic or Palæozoic mountain-chains any instance can be found so colossal as those of Tertiary times, such as the Alps. No volcanic eruptions of the older geological periods can compare in extent or volume with those of Tertiary and recent date. The plication and dislocation of the terrestrial crust are proportionately as conspicuously displayed among the younger as among the older formations, though the latter, from their greater antiquity, have suffered during a longer time from the renewed disturbances of successive periods.

As regards evidence of greater violence in the surrounding envelopes of atmosphere and ocean, we seek for it in vain among the stratified rocks. Among the very oldest formations of these Islands, the Torridon Sandstone of North-West Scotland presents us with a picture of long-continued sedimentation, such as may be seen in progress now round the shores of many a mountain-girdled lake. In that venerable deposit. the enclosed pebbles are not mere angular blocks and chips, swept by a sudden flood or destructive tide from off the surface of the land, and huddled together in confused heaps over the floor of the sea. They have been rounded and polished by the quiet operation of running water, as stones are rounded and polished now in the channels of brooks or on the shores of lake and sea. They have been laid gently down above each other, layer over layer, with fine sand sifted in between them, and this deposition has taken place along shores which, though the waters that washed them have long since disappeared, can still be followed for mile after mile across the mountains and glens of the North-West Highlands. So tranquil were these waters that their gentle currents and oscillations sufficed to ripple the sandy floor, to arrange the sediment in laminæ of current-bedding, and to separate the grains of sand according to their relative densities. We may even now trace the results of these operations in thin darker layers and streaks of magnetic iron, zircon, and other heavy minerals, which have been sorted out from the lighter quartz-grains, as layers of iron-sand may be seen sifted together by the tide along the upper margins of many of our sandy beaches at the present day.

In the same ancient formation there occur also various intercalations of fine muddy sediment, so regular in their thin alternations, and so like those of younger formations, that we cannot but hope and expect that they may eventually yield remains of organisms which, if found, would be the earliest traces of life in Europe.

It is thus abundantly manifest that even in the most ancient of the sedimentary registers of the earth's history, not only is there no evidence of colossal floods, tides, and denudation, but there is incontrovertible proof of continuous orderly deposition, such as may be witnessed to-day in any quarter of the globe. The same tale, with endless additional details, is told all through the stratified formations down to those which are in the course of accumulation at the present day.

Not less important than the stratigraphical is the palæontological evidence in favour of the general quietude of the geological processes in the past. The conclusions drawn from the nature and arrangement of the sediments are corroborated and much extended by the structure and manner of entombment of the enclosed organic remains. From the time of the very earliest fossiliferous formations there is nothing to show that either plants or animals have had to contend with physical conditions of environment different, on the whole, from those in which their successors now live. The oldest trees, so far as regards their outer form and internal structure, betoken an atmosphere neither more tempestuous nor obviously more impure than that of to-day. The earliest corals, sponges, crustaceans, mollusks, and arachnids were not more stoutly constructed than those of later times, and are found grouped together among the rocks as they lived and died, with no apparent indication that any violent commotion of the elements tried their strength when living or swept away their remains when dead.

But, undoubtedly, most impressive of all the palæontological data is the testimony borne by the grand succession of organic remains among the stratified rocks as to the vast duration of time required for their evolution. Professor Poulton has treated this branch of the subject with great fulness and ability. We do not know the present average rates of organic variation, but all the available evidence goes to indicate their extreme slowness. They may conceivably have been more rapid in the past, or they may have been liable to fluctuations according to vicissitudes of environment.[1] But those who assert that the rate of biological evolution ever differed materially from what it may now be inferred to be, ought surely to bring forward something more than mere assertion in their support. In the meantime, the most philosophical course is undoubtedly followed by those biologists who in this matter rest their belief on their own experience among recent and fossil organisms.

So cogent do these geological and palæontological arguments appear to those at least who have taken the trouble to master them, that they are worthy of being employed, not in defence merely, but in attack. It seems to me that they may be used with effect in assailing the stronghold of speculation and assumption in which our physical friends have ensconced themselves and from which, with their feet, as they believe, planted well within the interior of the globe and their heads in the heart of the sun, they view with complete unconcern the efforts made by those who endeavour to gather the truth from the surface and crust of the earth. That portion of the records of terrestrial history which lies open to our investigation has been diligently studied in all parts of the world. A vast body of facts has been gathered together from this extended and combined research. The chronicle registered in the earth's crust, though not complete, is legible and consistent. From the latest to the earliest of its chapters the story is capable of clear and harmonious interpretation by a comparison of its pages with the present condition of things. We know infinitely more of the history of this earth than we do of the history of the sun. Are we, then, to be told that this knowledge, so patiently accumulated from innumerable observations and so laboriously co-ordinated and classified, is to be held of none account in comparison with the conclusions of physical science in regard to the history of the central luminary of our system? These conclusions are founded on assumptions which may or may not correspond with the truth. They have already undergone revision, and they may be still further modified as our slender knowledge of the sun, and of the details of its history, is increased by future investigation. In the meantime, we decline to accept them as a final pronouncement of science on the subject. We place over against them the evidence of geology and palæontology, and affirm that unless the deductions we draw from that evidence can be disproved, we are entitled to maintain them as entirely borne out by the testimony of the rocks.

Until, therefore, it can be shown that geologists and palæontologists have misinterpreted their records, they are surely well within their logical rights in claiming as much time for the history of this earth as the vast body of evidence accumulated by them demands. So far as I have been able to form an opinion, one hundred millions of years would suffice for that portion of the history which is registered in the stratified rocks of the crust. But if the palæontologists find such a period too narrow for their requirements, I can see no reason on the geological side why they should not be at liberty to enlarge it as far as they may find to be needful, for the evolution of organized existence on the globe. As I have already remarked, it is not the length of time which interests us so much as the determination of the relative chronology of the events which were transacted within that time. As to the general succession of these events, there can be no dispute. We have traced its stages from the bottom of the oldest rocks up to the surface of the present continents and the floor of the present seas. We know that these stages have followed each other in orderly advance, and that geological time, whatever limits may be assigned to it, has sufficed for the passage of the long stately procession.

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[1] See an interesting and suggestive paper by Professor Le Conte on "Critical Periods in the History of the Earth": Bull. Dept. Geology, University of California, vol. i (1895), p. 313. Also one by Professor Chamberlin on "The Ulterior Basis of Time-divisions and the Classification of Geological History": Journal of Geology, vol. vi (1898), p. 449.

We may, therefore, well leave the dispute about the age of the earth to the decision of the future. In so doing, however, I should be glad if we would carry away from it something of greater service to science than the consciousness of having striven our best in a barren controversy, wherein concession has all to be on one side and the selection of arguments entirely on the other. During these years of prolonged debate I have often been painfully conscious that in this subject, as in so many others throughout the geological domain, the want of accurate numerical data is a serious hindrance to the progress of our science. Heartily do I acknowledge that much has been done in the way of measurements and experiments for the purpose of providing a foundation for estimates and deductions. But infinitely more remains to be accomplished. The field of investigation is almost boundless, for there is hardly a department of geological dynamics over which it does not extend. The range of experimental geology must be widely enlarged, until every process susceptible of illustration or measurement by artificial means has been investigated. Field-observation needs to be supplemented where possible by instrumental determinations, so as to be made more precise and accurate, and more capable of furnishing reliable numerical statistics for practical as well as theoretical deductions.

The subject is too vast for adequate treatment here. But let me illustrate my meaning by selecting a few instances where the adoption of these more rigid methods of inquiry might powerfully assist us in dealing with the rates of geological processes and the value of geological time. Take, for example, the wide range of lines of investigation embraced under the head of Denudation. So voluminous a series of observations has been made in this subject, and so ample is the literature devoted to it, that no department of geology, it might be thought, has been more abundantly and successfully explored. Yet if we look through the pile of memoirs, articles, and books, we cannot but be struck with the predominant vagueness of their statements, and with the general absence of such numerical data determined by accurate, systematic, and prolonged measurement as would alone furnish a satisfactory basis for computations of the rate at which denudation takes place. Some instrumental observations of the greatest value have indeed been made, but for the most part observations of this kind have been too meagre and desultory.

A little consideration will show that in all branches of the investigation of denudation opportunities present themselves on every side of testing, by accurate instrumental observation and measurement, the rate at which some of the most universal processes in the geological régime of our globe are carried on.

It has long been a commonplace of geology that the amount of the material removed in suspension and solution by rivers furnishes a clue to the rate of denudation of the regions drained by the rivers. But how unequal in value, and generally how insufficient in precision, are the observations on this topic! A few rivers have been more or less systematically examined, some widely varying results have been obtained from the observations, and while enough has been obtained to show the interest and importance of the method of research, no adequate supply of materials has been gathered for the purposes of accurate deduction and generalization. What we need is a carefully organized series of observations carried out on a uniform plan, over a sufficient number of years, not for one river only, but for all the important rivers of a country, and, indeed, for all the greater rivers of each continent. We ought to know as accurately as possible the extent of the drainage-area of each river, the relations of river-discharge to rainfall and to other meteorological as well as topographical conditions; the variation in the proportions of mechanical and chemical impurities in the river-water according to geological formations, form of the ground, season of the year, and climate. The whole geological régime of each river should be thoroughly studied. The admirable report of Messrs. Humphreys and Abbot on the "Physics and Hydraulics of the Mississippi," published in 1861, might well serve as a model for imitation, though these observers necessarily occupied themselves with some questions which are not specially geological and did not enter into others on which, as geologists, we should now gladly have further information.

Again, the action of Glaciers has still less been subjected to prolonged and systematic observation. The few data already obtained are so vague that we may be said to be still entirely ignorant of the rate at which glaciers are wearing down their channels and contributing to the denudation of the land.

The whole of this inquiry is eminently suitable for combined research. Each stream or glacier, or each well-marked section of one, might become the special inquiry of a single observer, who would soon develop a paternal interest in his valley and vie with his colleagues of other valleys in the fulness and accuracy of his records.

Nor is our information respecting the operations of the Sea much more precise. Even in an island like Great Britain, where the waves and tides effect so much change within the space of a human lifetime, the estimates of the rate of advance or retreat of the shoreline are based for the most part on no accurate determinations. It is satisfactory to be able to announce that the Council of this Association has formed a Committee for the purpose of obtaining full and accurate information regarding alterations of our coasts, and that with the sanction of the Lords of the Admiralty the co-operation of the Coastguard throughout the three kingdoms has been secured. We may therefore hope to be eventually in possession of trustworthy statistics on this interesting subject.

The disintegration of the surface of the land by the combined agency of the Subaërial forces of decay is a problem which has been much studied, but in regard to whose varying rates of advance not much has been definitely ascertained. The meteorological conditions under which it takes place differ materially according to latitude and climate, and doubtless its progress is equally variable. An obvious and useful source of information in regard to atmospheric denudations is to be found in the decay of the material of buildings of which the time of erection is known, and in dated tombstones. Twenty years ago I called attention to the rate at which marble gives way in such a moist climate as ours, and cited the effects of subaërial waste as these can be measured on the monuments of our graveyards and cemeteries.[1] I would urge upon town geologists, and those in the country who have no opportunities of venturing far afield, that they may do good service by careful scrutiny of ancient buildings and monuments. In the churchyards they will find much to occupy and interest them, not, however, like Old Mortality, in repairing the tombstones, but in tracing the ravages of the weather upon them, and in obtaining definite measures of the rate of their decay.

The conditions under which subaërial disintegration is effected in arid climates, and the rate of its advance, are still less known, seeing that most of our information is derived from the chance observations of passing travellers. Yet this branch of the subject is not without importance in relation to the denudation not only of the existing terrestrial surface but of the lands of former periods, for there is evidence of more than one arid epoch in geological history. Here, again, a diligent examination of ancient buildings and monuments might afford some, at least, of the required data. In such a country as Egypt, for instance, it might eventually be possible to determine from a large series of observations what has been the average rate of surface-disintegration of the various kinds of stone employed in human constructions that have been freely exposed to the air for several thousand years.

Closely linked with the question of denudation is that of the Deposition of the material worn away from the surface of the land. The total amount of sediment laid down must equal the amount of material abstracted, save in so far as the soluble portions of that material are retained in solution in the sea. But we have still much to learn as to the conditions, and especially as to the rate of, sedimentation. Nor does there appear to be much hope of any considerable increase to our knowledge until the subject is taken up in earnest as one demanding and justifying a prolonged series of well-planned and carefully executed observations. We have yet to discover the different rates of deposit, under the varying conditions in which it is carried on in lakes, estuaries, and the sea. What, for instance, would be a fair average for the rate at which the lakes of each country of Europe are now being silted up? If this rate were ascertained, and if the amount of material already deposited in these basins were determined, we should be in possession of data for estimating not only the probable time when the lakes will disappear, but also the approximate date at which they came into existence.

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[1] Proc. Roy. Soc. Edin., vol. x (1879–80), p. 518.

But it is not merely in regard to epigene changes that further more extended and concerted observation is needed. Even among subterranean movements there are some which might be watched and recorded with far more care and continuity than have ever been attempted. The researches of Professor George Darwin and others have shown how constant are the tremors, minute but measurable, to which the crust of the earth is subject.[1] Do these phenomena indicate displacements of the crust, and, if so, what in the lapse of a century is their cumulative effect on the surface of the land?

More momentous in their consequences are the disturbances which traverse mountain-chains and find their most violent expression in shocks of earthquake. The effect of such shocks have been studied and recorded in many parts of the world, but their cause is still little understood. Are the disturbances due to a continuation of the same operation which at first gave birth to the mountains? Should they be regarded as symptoms of growth or of collapse? Are they accompanied with even the slightest amount of elevation or depression? We cannot tell. But these questions are probably susceptible of some more or less definite answer. It might be possible, for instance, to determine with extreme precision the heights above a given datum of various fixed points along such a chain as the Alps, and by a series of minutely accurate measurements to detect any upward or downward deviation from these heights. It is quite conceivable that throughout the whole historical period some deviation of this kind has been going on, though so slowly, or by such slight increments at each period of renewal, as to escape ordinary observation. We might thus learn whether, after an Alpine earthquake, an appreciable difference of level is anywhere discoverable, whether the Alps as a great mountain-chain are still growing or are now subsiding, and we might be able to ascertain the rate of the movement. Although changes of this nature may have been too slight during human experience to be ordinarily appreciable, their very insignificance seems to me to supply a strong reason why they should be sought for and carefully measured. They would not tell us, indeed, whether a mountain-chain was called into being in one gigantic convulsion, or was raised at wide intervals by successive uplifts, or was slowly elevated by one prolonged and continuous movement. But they might furnish us with suggestive information as to the rate at which upheaval or depression of the terrestrial crust is now going on.

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[1] Report Brit. Assoc., 1882, p. 95.

The vexed questions of the origin of Raised Beaches and Sunk Forests might in like manner be elucidated by well-devised measurements. It is astonishing upon what loose and unreliable evidence the elevation or depression of coast-lines has often been asserted. On shores where proofs of a recent change of level are observable it would not be difficult to establish by accurate observation whether any such movements are taking place now, and, if they are, to determine their rate. The old attempts of this kind along the coasts of Scandinavia might be resumed with far more precision and on a much more extended scale. Methods of instrumental research have been vastly improved since the days of Celsius and Linnæus. Mere eye-observations would not supply sufficiently accurate results. When the datum-line has been determined with rigorous accuracy, the minutest changes of level, such as would be wholly inappreciable to the senses, might be detected and recorded. If such a system of watch were maintained along coasts where there is reason to believe that some rise or fall of land is taking place, it would be possible to follow the progress of the movement and to determine its rate.

But I must not dwell longer on examples of the advantages which geology would gain from a far more general and systematic adoption of methods of experiment and measurement in elucidation of the problems of the science. I have referred to a few of those which have a more special bearing on the question of geological time, but it is obvious that the same methods might be extended into almost every branch of geological dynamics. While we gladly and gratefully recognize the large amount of admirable work that has already been done by the adoption of these practical methods, from the time of Hall, the founder of experimental geology, down to our own day, we cannot but feel that our very appreciation of the gain which the science has thus derived increases the desire to see the practice still further multiplied and extended. I am confident that it is in this direction more than in any other that the next great advances of geology are to be anticipated.

While much may be done by individual students, it is less to their single efforts than to the combined investigations of many fellow-workers that I look most hopefully for the accumulation of data towards the determination of the present rate of geological changes. I would, therefore, commend this subject to the geologists of this and other countries as one in which individual, national, and international co-operation might well be enlisted. We already possess an institution which seems well adapted to undertake and control an enterprise of the kind suggested. The International Geological Congress, which brings together our associates from all parts of the globe, would confer a lasting benefit on the science if it could organize a system of combined observation in any single one of the departments of inquiry which I have indicated or in any other which might be selected. We need not at first be too ambitious. The simplest, easiest, and least costly series of observations might be chosen for a beginning. The work might be distributed among the different countries represented in the Congress. Each nation would be entirely free in its selection of subjects for investigation, and would have the stimulus of co-operation with other nations in its work. The Congress will hold its triennial gathering next year in Paris, and if such an organization of research as I have suggested could then be inaugurated, a great impetus would thereby be given to geological research, and France, again become the birthplace of another scientific movement, would acquire a fresh claim to the admiration and gratitude of geologists in every part of the globe.

II. — BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Sixty-ninth Annual Meeting, held at Dover, September 14–20, 1899.

LIST OF PAPERS READ IN SECTION C, GEOLOGY.

Sir ARCHIBALD GEIKIE, D.C.L., F.R.S., F.G.S., President.

Presidential Address by Sir A. Geikie (read 16th September).

R. Etheridge, F.R.S. — On the Relations between the Dover and Franco-Belgian Coal-Basins.

Professor W. Boyd Dawkins, F.R.S.—On the South-Eastern Coalfield.[1]

A. J. Jukes-Browne.—Note on a Boring through the Chalk and Gault near Dieppe.

Walcot Gibson.—Some recent Work among the Upper Carboniferous of North Staffordshire and its Bearings on concealed Coalfields.

E. Greenly.—Report of the Committee on the Drift Sections at Moel Tryfan.

C. B. Wedd.—Note on Barium Sulphate in the Bunter Sandstone of North Staffordshire.

Professor J. Milne, F.R.S.—Report of the Committee on Seismological Investigations.

Professor H. A. Miers, F.R.S.— Report of the Committee on the Structure of Crystals.

E. J. Garwood.—Report of the Committee on Life Zones in British Carboniferous Rocks.

Dr. A. W. Rowe.—The Photo-Micrography of Opaque Objects as applied to Delineation of the Minute Structure of Fossils. (Lantern.)

Dr. G. Abbott.—Water Zones: their Influence on the Situation and Growth of Concretions. (Lantern.)

——— Tubular and Concentric Concretions. (Lantern.)

E. Greenly.—On Photographs of Sandstone Pipes in the Carboniferous Limestone at Dwlbau Point, East Anglesey. (Lantern.)

——— Glaciation of Dwlbau Point, East Anglesey. (Lantern.)

P. F. Kendall.—Extra-Morainic Drainage in Yorkshire. (Lantern.)

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[1] Professor W. Boyd Dawkins' diagrams of the new coal borings in Kent were on view in the Section Room.

J. Lomas.—On the Origin of Lateral Moraines and Rock Trains. (Lantern.)

Professor W. J. Sollas, F.R.S.—Note on the Origin of Flint. (Lantern.)

Dr. H. J. Johnston-Lavis.—The Structure of Oolite and Calcareous Confetti. (Lantern.)

Rev. G. C. H. Pollen.—Report of the Committee on the Ty Newydd Caves. (Lantern.)

Professor T. Rupert Jones, F.R.S.—Report of the Committee on Palæozoic Phyllopoda.

Professor W. J. Sollas, F.R.S.—On Homotaxy and Contemporaneity.

Professor W. W. Watts.—On the Rounded Surfaces of the Mount Sorrel Granite.

Professor A. Renard.—On the Origin of Chondritic Meteorites.

Captain McDakin.—On Coast Erosion. (Lantern.)

G. Dowker.—Coast Erosion. (Lantern.)

W. Whitaker, F.R.S.—Preliminary Report on Coast Erosion.

Vaughan Cornish.—On Photographs of Wave Phenomena. (Lantern.)

Dr. Tempest Anderson.—Note on the Eruption of Vesuvius in September, 1898. (Lantern.)

Professor G. Platania.—On Mount Etna and its recent Volcanic Phenomena.

Professor P. F. Kendall.—Investigation of the Underground Waters of Craven. Part I: The Sources of the Aire. (Lantern.)

Professor W. Boyd Dawkins, F.R.S.—On the Geology of the Channel Tunnel.

F. W. Harmer.—On a proposed New Classification of the Pliocene Deposits of the East of England.

——— The Meteorological Conditions of North-Western Europe during the Pliocene and Glacial Periods.

Professor W. W. Watts.—Report of the Committee on British Photographs of Geological Interest.[1]

Rev. J. M. Mello.—A note on some Palæolithic Implements of North Kent.

P. M. C. Kermode.—Report of Committee on Irish Elk Remains in the Isle of Man.

Professor A. P. Coleman.—Report of the Committee on the Flora and Fauna of the Interglacial Beds in Canada.

Mrs. Maria M. (Ogilvie) Gordon, D.Sc.—On Sigmoidal Curves in the Earth's Crust.

H. Bolton.—Report of the Committee on the Ossiferous Caves at Uphill.

Professor P. F. Kendall.—Report of the Committee on Erratic Blocks of the British Isles.

Dr. H. M. Ami.—On the Subdivisions of the Carboniferous System in certain portions of Nova Scotia.

A. Smith Woodward.—Report of the Committee on the Registration of Type Specimens.

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[1] A series of geological photographs was exhibited by the Committee for the Collection and Preservation of Geological Photographs in the Committee Room.

III.—A PALÆOZOIC TERRANE BENEATH THE CAMBRIAN. By GEO. F. MATTHEW. [Annals New York Acad. Sci., vol. xii, No. 2, pp. 41–56.]

THIS article describes an unconformable series of rocks below the true Cambrian measures, containing *Paradoxides* and *Agraulos strenuus*, and therefore claimed to be pre-Cambrian. The series has been observed in Canada (Southern New Brunswick) and Newfoundland, in both of which countries the erosion of the underlying terrane (Etcheminian) to a greater or less extent had occurred before the deposition of the Cambrian.

Remains of a fauna had been found in these beds in New Brunswick, but only of a fragmentary kind, and only low organisms had, as a rule, been recognized. The Newfoundland beds yielded better results, and Mr. Matthew now records from the terrane the following forms:—

Hyolithes 2 species, *Orthotheca* 4 sp., *Urotheca* (n.gen.) 1 sp., *Aptychopsis* 1 sp., *Kutorgina* (?) 1 sp., *Obolella* 1 sp., *Obolus* 1 sp., *Coleoidea* 1 sp., *Hyolithellus* 2 sp., *Helenia* 1 sp., *Palæaomæa* 1 sp., *Scenella* 2 sp., *Platyceras* 3 sp., *Modiolopsis* 1 sp., *Platysolenites* (?) 1 sp. Besides these there are fragments of Cystidians and burrows and trails of worms.

"The uniformity of conditions attending the deposition of the Etcheminian throughout the Atlantic Coast province of the Cambrian is surprising, and point to a quiescent period of long continuance, during which the Hyolithidæ and Capulidæ developed so as to become the dominant types of the animal world, while the Brachiopods, the Lamellibranchs, and the other Gasteropods still were puny and insignificant."

REVIEWS.

I.—THE SURVEY MEMOIR ON THE SCOTTISH UPLANDS.[1]

I HAVE been requested by my friend the Editor of the GEOLOGICAL MAGAZINE to review this latest, finest, and most original of the monographs issued by the British Geological Survey; and although for many reasons I should have preferred that the request had been made to some younger geologist, and one less personally interested in the subject, yet as an old worker in the Upland region to which the volume is devoted, an opponent of the old ideas of the succession, and an advocate of the new, I have no choice but to comply.

In the first place attention must be directed to the great advance which this monograph shows upon the previous Survey publications of the corresponding type as regards external get-up, paper, printing, illustrations, and last, but by no means least, reasonableness in price. We have here a handsome volume, a large octavo of some

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[1] Memoirs of the Geological Survey of the United Kingdom: "The Silurian *Rocks of Britain*," vol. i, Scotland, 1899.

750 pages, printed clearly upon good paper, illustrated by about 120 cuts of sections, sketch plans, and the like scattered through the letterpress, together with 18 full-page plate reproductions of excellent photographs of typical field-sections and field-structures, all printed in a manner to do them full justice; while in addition we have seven equally good full-page reproductions of microphotographic rock-structures collected at the end of the volume, two full-page plates of fossils, and a coloured index map and index sections of the region surveyed; and all for the modest price of 15*s*. It is to be hoped that now the Survey officers have thus demonstrated the possibility of issuing to the public a work in all these respects worthy of the Survey, they will insist that no future monograph shall fall below this standard.

For this is precisely as it should be. It is but reasonable, to say the least, that this national Survey, the current cost of which is borne by the people, should do its utmost to publish its results in the form most attractive and beneficial to the people, and at the lowest possible price; that the results of the Survey work—their maps and their memoirs—should be taken advantage of by as large a number of people as possible, not only for the sake of the advancement of the material prosperity of the country, but for the sake of the progress and influence of British geological knowledge at large.

To lovers of British geology it is mortifying to acknowledge how few persons, educated or uneducated, know, or care to know, anything of that science which of all sciences is the one pre-eminently British. And yet how naturally does every well-read geologist, not only British, but foreign, accept it as a trite and open secret that the primal source and foundation of the upward progress of our country, from the days of the great Elizabeth to those of the greater Victoria, has been the vast store of mineral wealth that Nature has placed around the homes and under the very feet of our people—a store of mineral wealth which, when contrasted with the insignificant size of the country, is equalled in no other land under the sun. Talk of the great landed nobles as we may, boast of the sturdy yeomen of the land and the hardy sailors of the seas, yet at the back of them all, back of all our national progress and prestige, lie the great coalfields and ironfields. that have founded and fed the great manufacturing districts. These in their turn have furnished employment and subsistence to our teeming populations, have brought wealth, leisure, influence to our middle classes; and have afforded to the nation at large the means of trade and intercommunication at home, of transport and commerce on the seas, and of conquest and colonization abroad.

And how thoroughly does every well-seasoned British geologist know that the vast extent and sway of our political British empire, upon which we boast that the sun never sets, is more than paralleled by the worldwide rule and dominance of the British empire of geological principles and ideas—an empire to which every geologist living takes by implication the oath of allegiance the day he becomes a geologist. The host of the political British colonies and possessions scattered over the continents and the oceans, what are they to the host of British colonies and settlements scattered throughout the geological literature and practice of the entire geological world? Not a single map of any large district issued by the Geological Survey of any country, not a geological text-book published in any language, not a geological lecture delivered by any teacher, or a geological paper read by any amateur, from London to Tokio, from the St. Lawrence to the Plate, but shows how the geological nomenclature of every land has been colonized verbally by British settlers, who, in their stiff, self-sufficient, masterful way, enforce order and contentment among the aborigines around.

Of course, to the old geological hand all these things are but prosy platitudes—contemptible because they are so familiar. But who knows? Some day, perhaps, may arise a Kipling, who shall suddenly touch with them, burning, the hearts of the people, that they may open their eyes and see.

In the meantime, however, it is good to know that the science of geology is still advancing amongst us from discovery to discovery, that the amateur geologist is still one of the natural products of the British soil. It is pleasant also to note how the national Geological Survey issues year after year its maps and its memoirs, not only those dealing with areas well known of old to be conspicuous for their abundant mineral resources, or fruitful in geological interest, but also with areas which for the time being may seem to be but barren and desolate solitudes in both regards. And this, again, is but right. Who among the officers of those surveying ships of Britain, sent out a century or two ago to map the unknown coasts of America, Africa, and Australia, imagined even in their wildest dreams that the lonely lands they outlined would, in the no long distant future, teem with English-speaking populations, the pride of the mother country, and rich, powerful, and prosperous, for whose safe and certain advent these early surveys had prepared the road? Who, again, among British geologists, official or non-official, can take upon himself to say what hosts of new and important geological facts, rich in new deductions destined to advance the honour of British science, or to add to the wealth of the country, intellectual or material, may not follow from the careful mapping of apparently unpromising areas?

We have, indeed, a very good illustration of this in the case of the region described by the memoir we are reviewing. The Geological Surveyors, as in duty bound, practically deferred the complete mapping of this apparently unpromising region until all the neighbouring parts of Scotland, rich in materials of economic value, had been surveyed and mapped. Stage by stage, however, the Upland work has been taken up, until at last we have a complete outline picture of the structure and possibilities of the region. And in place of the older view of the unpromising nature of its geological formations they are found to be wonderfully rich in geological facts and phenomena, needing for their explanation and classification a new race, so to speak, of unexpected geological conclusions and principles, destined to play an important part in the future of British geology.

In their original mapping of the Uplands, between 1854 and 1873, the officers of the Survey followed the familiar formational or regional plan of working out the succession, classing each broad geographical belt of strata having as a whole special and characteristic lithological features as the outcrop of a distinct rock group or formation, fixing its relative place in the general series of such formations by its visible superposition, and its approximate geological age by its collective fauna; a method which had proved itself in every case fully adequate for the ascertainment of the true sequence among the Lowland formations of Britain, and even among the tilted Silurian rocks of Wales, the North of England, Lanarkshire, and the Pentlands. Combining the work of all their predecessors with the results of their own researches, and interpreting the whole in this way, they concluded that the strata of the Uplands dipped off a grand anticlinal form ranging from Dumfries to St. Abbs, and that its highest formation, the geological age of which was fixed by its Caradoc fossils, lay in the lap of a synclinal form running through the Leadhills to the Moorfoots. Between the anticlinal line and the synclinal form occurred a series of seven rock-groups or sub-formations: (1) the axial or Ardwell beds, (2) the Moffat Black Shales, (3) the Queensberry Grits, (4) the Dalveen Group, (5) the Lowther Shales, (6) the Leadhills Black Shales, and (7) the Carsphairn Grit Group. These were all classed as being of Llandeilo age, for most of them afforded certain well-known Llandeilo graptolites. It was true the strata were often so folded that it was impossible to say whether we were ascending or descending in the order of the beds, but the general sequence appeared evident enough. It was true that with the Llandeilo graptolites were often intermixed forms known in so-called Caradoc and higher strata in other parts of Britain, but the well-known and generally accepted Theory of Colonies of the illustrious Barrande was supposed by many to afford a very simple and natural explanation of such anomalies.

But the facts ascertained and the results arrived at stage by stage by myself and others in the geology of this Upland region, more especially in the Moffat and Girvan districts (1872–1882), made it evident that the regional or formational plan of mapping these convoluted rocks of the Uplands was unreliable, and that the only method found invariably trustworthy was that of working by means of palæontological and lithological 'zones.' The host of evidences accumulated during the same period by geologists and palæontologists in Britain, Scandinavia, France, America, etc., that the Silurian Graptolite was as capable as the Jurassic Ammonite of being employed as a stratigraphical index, made it equally plain that the true sequence of the Silurian strata from end to end of the Uplands must of necessity be that of their zones of graptolites.

It was not, however, until 1888 that the officers of the Survey felt the necessity—or, to speak more accurately, found the time and the opportunity—for testing the general reliability of these zonal ideas in the Uplands as a whole, and of revising the geology in the full light of the new methods.

Looking back over the whole matter from our present standpoint, we see that there is little or no room for astonishment or regret at this delay. Although—and to their lasting honour be it said—the new ideas were from the first heartily welcomed by the Geological Societies, and adopted by the younger and more ardent geologists, they were long looked at askance by many of those geologists well qualified to judge of their value and their applicability.

Consider for a moment the demands the novel results and conclusions due to the zonal method made upon the common-sense and experience — I will not say credulity — of those British geologists who had spent many of the best years of their life face to face with Silurian rocks in the field, had often worked side by side with the great leaders in reducing them to order, and had the literature of the subject at their finger-ends.

The data upon which the older views of the Upland succession rested were those which naturally appealed to the experience of the true field geologist. They were first and foremost petrological. They were few in number, easy to obtain, and easy to interpret. The sequence followed, as it were, almost of itself, from the common-sense deductions which would be drawn by any ordinary geologist taking broad views of every-day field phenomena. The tectonic structure corresponding to this succession showed, even more conspicuously than usual, the deformed character of districts floored by the more ancient rock formations. And lastly, the simple theoretical picture this succession gave us of the physical conditions of the region in Silurian times showed us little or nothing that previous knowledge or opinion had not led us to expect.

But, on the other hand, the newer views of the succession were founded essentially upon palæontological considerations, and petrology was relegated to a place in the background. They were dependent upon the harmonizing of a host of minor and local details, always difficult and sometimes impossible to obtain; and the final results were confessedly, after all, first approximations to the truth. In the discussion of the bearing of these new results upon the Upland structure, the evidence of the senses was put out of court, and field experience and ordinary judgment flouted with paradoxes. Finally, when from all the results thus arrived at we attempted an explanatory picture of the physical conditions in Silurian time, the imagination seemed to run riot amid the unfamiliar and the unexpected.

If, in surveying these convoluted Upland strata, we restrict ourselves to the older and simpler regional or formational methods of mapping by broad mineralogical characters and visible superposition, we are forced to disbelieve in the individual graptolite *species* as a geological index. We are led quite naturally to the earlier Survey view that the visibly ascending sequence of Upland lithological rock-bands is that of a geologically ascending succession of Silurian rock formations, embracing some eight distinct rock groups, all of which (except the highest) form, as shown by their *collective* graptolite fauna, a series of ascending stages in one general Upper Llandeilo series. The lowest formation of this Llandeilo series dips visibly off the great longitudinal anticlinal axis of Hawick and Dumfries, and its highest subsides below the core of the great Leadhills' synclinal form. Collectively, this series must be of enormous thickness, but is remarkably monotonous both as regards mineralogical character and fossils. And, judging from all these conclusions, it would appear that in Upper Llandeilo times this was a region of shallow and muddy seas, in which there was for ages little or no change in the physical conditions and little or no progress in the evolution of organic life.

If, on the contrary, we follow the newer and more complicated zonal methods of mapping the Uplands—in other words, by detailed criteria primarily palæontological—we soon find ourselves shut up to the conclusion that the graptolite species, instead of being, as was formerly believed, one of the most untrustworthy of geological witnesses, is in reality one upon whose testimony the stratigraphist can implicitly rely. We gather that the conclusions drawn from the evidences it affords accord perfectly with the detailed lithological evidences and the like; they allow us so to explain and correlate the ascertainable petrological and palæontological phenomena from end to end of the Upland region, that they afford us a clue to the true arrangement of its strata and the key to its structure.

We learn that the grand geographical rock-bands of the Uplands are not the outcrops of an ascending series of distinct rock-groups, but answer, broadly speaking, to those of the different lithological variations of strata laid down in the same geological period, as they slowly change in mineral character and in thickness when followed from the ancient Silurian shore-lines towards the depths of the seas.

We find that not only is the petrological distinctness of the various rock-bands no proof of their individuality, but that the relative thickness of such Upland formations as we can individualize has no relation to their relative geological importance. The insignificant group of the Moffat Shales, only some 300 feet in thickness, formerly classed as a mere subdivision of the Upland Llandeilo, is the representative in time of the three great Welsh formations, the Upper Llandeilo, the Bala, and the Llandovery, and, like them, is marked by three distinct faunas. On the other hand, the Upland Gala or Queensberry formation, 25 miles in breadth and many thousands of feet in thickness, must be looked upon merely as a magnified representative of the band of Tarannon Shale, which in Wales is only about 1,000 feet in thickness, and marks the transitional period of time between the Llandovery and the Wenlock.

But not only are many of the stratigraphical generalizations drawn from broad regional views of the strata of the Upland region thus superseded by others due to the application of the zonal methods, but also many of the tectonic conclusions drawn from broad views of its apparently simple tectonic structure. Two examples must here suffice. The new reading of the succession interprets the widest visible 'synclinal' of the Leadhills as its broadest anticlinal form, and regards the 'anticlinal' of Dumfries and Hawick—the very backbone of the Uplands—merely as a squeezed-in synclinal of no stratigraphical importance whatsoever.

Nor would the theoretical picture of the physical conditions of the Upland region in Silurian times, drawn by any student of the zonal methods, bear much resemblance to that limned by anyone who had mapped the country on the old regional plan.

The detailed phenomena worked out by the zonal method call upon us, explicitly or implicitly, to believe that in Arenig and Llandeilo times where now in part the Scottish Uplands rise there lay a region of broad, deep, and clear seas, over which the slowly moving currents drifted floating fields of tangle and seaweed, from which, perhaps, hung suspended the plant-like graptolites. Into these clear seas came for ages little or no land-derived sediment, save now and again the dust from a distant volcano. Their deep waters were bordered to the north-west by islanded shores, at first crowned by active volcanoes, but afterwards buried up with many oscillations under massive sheets of pebbles, sand, and mud, often marvellously prolific in animal life. Slowly the floor of the deep sea became shallowed, and the shore-derived sediments travelled farther and farther seaward, each formation in the earlier part of the ascending series thus showing a gradual thickening in a landward direction, each formation in the later part showing an increased thickening as a whole. By the close of Silurian times the sea-floor had all emerged as solid land to face the wear and tear of rain and rivers, having in the process of time become wrinkled and folded in a most marvellous way. To-day, after eons of denudation, the old rock formations of Silurian times, thick and massive in the direction of the ancient shore-lines, thinning away almost to nothing where lay the deeps of the seas, still lie, each in contact, it is true, with its natural predecessor and successor in time; but so wrinkled and jammed together are they, so twisted and tangled locally, that only by studying each rock-sheet thread by thread, as it were, where it shows out now and again through the rents and the tatters of the sheet now above it, can we say with certainty which of those sheets it is we are studying, and what were the local circumstances of its deposition.

These are a few of perhaps the most striking contrasts between the results obtained by the interpretation of the phenomena presented by the convoluted rocks of the Uplands: on the one hand, by the older and simple *formational*, collective, or areal methods, as followed by Nicol, Sedgwick, Murchison, Harkness, and others, and the officers of the Survey up to the year 1873; and on the other hand, by those who have used, in whole or in part, the newer and more complicated *zonal* methods, as developed by British and foreign geologists, broadly speaking, between the years 1870 and 1886.

Before, therefore, any general memoir upon the Silurian rocks of

Britain could be issued by the Survey, it was evident that the old formational views of the Upland succession must first be rigidly tested in the field in the light of the more recent discoveries and opinions; and in the year 1888 Messrs. Peach and Horne, already long familiar with zonal methods in their brilliant work in the North-West Highlands, were deputed by the Director-General to make a complete revision of the Upland geology. During the years 1888–1899 they have from time to time been busied at this task. In the words of Sir Archibald Geikie in his preface to the book, "they have traversed, sometimes repeatedly, the various sections of the strata across the length and breadth of the Southern Uplands. They have mapped on the ground the successive rock-zones, traced the variation of these zones from one end of the region to the other, and made voluminous notes as regards their stratigraphy and palæontology."

The greater part of the present volume is the result of this revision, which, it is plainly evident, has been to all concerned a labour of love. CHAS. LAPWORTH.

(*To be concluded.*)

II.—APPLIED GEOLOGY. Part II. By J. V. ELSDEN, B.Sc., F.G.S. 8vo; pp. vi, 250. (London: "The Quarry" Publishing Co., 1899.)

THE first part of this work, a slim volume bound in cloth, was noticed in the GEOLOGICAL MAGAZINE for November, 1898 (p. 521). We then referred to the difficulties of the task which the author had undertaken. Evidently he has devoted great pains to his work, but, as might be expected, he cannot deal equally nor sufficiently fully with all sections of such a very comprehensive subject. As an introduction to the student and as an aid to the teacher, the book will no doubt be found useful; but there can be no question that the mining engineer, and those who require special information concerning building-stones, cements, water-supply, etc., must seek it in works dealing particularly with those subjects.

The author has gleaned facts from all parts of the world, and from a number of original sources, but he only occasionally acknowledges the information which he has utilized in the text, and in the accompanying illustrations. There is perhaps too great a tendency nowadays to regard published information (both text and figures) as common property, and to avoid burdening the text with references; but we cannot help thinking that the value of the present work would have been enhanced by references to works in which fuller information could be obtained. The illustrations (a few of which are acknowledged) have been reproduced in a bold diagrammatic style. A number of microscopic sections of rocks are also introduced, but on this subject, as on some others where special knowledge and training are essential, a little knowledge may be a dangerous thing.

The present work begins with chapter vi, thus continuing the subject-matter of Part I. but the paging is commenced anew. The author now deals with ore-deposits, building and ornamental stones, and other rocks used in the arts and manufactures, with engineering geology and soils. In ascertaining the mode of occurrence and extent of various deposits of economic importance, a scientific knowledge of the structure of the ground is essential. In metalliferous regions it is needful to know the character of the plications as well as the nature of the rocks. The width of lodes may vary with rocks of different texture, and cavities filled with mineral matter may be expected at particular points in flexured rocks.

After giving some account of unstratified ore-deposits, the author briefly refers in chapter vii to peat, lignite, coal, and petroleum, and also to phosphates, rock-salt, gypsum, and cobalt. We cannot say that the author's treatment of his subject is systematic. In chapter viii we are told something about prospecting and developing, and the recognition of minerals, and also about quarrying and mining. Thence we pass on, in chapter ix, to building and ornamental stones. Here the author commences with a general account of igneous rocks, of dykes and sills and laccolites, and gives a short glossary of terms applied to rock-structures, a classification of igneous rocks, and a list of their chief rock-forming minerals. He then deals briefly with causes of weathering in building stones, a subject discussed subsequently in several chapters. In chapter xiii we have accounts of lithographic stone, lime and cement, brick and pottery clays, fire-clays, sands, grindstones, bath bricks, pigments, gems, and artificial stone. Fuller's earth is briefly mentioned, but that of Nutfield and Woburn should have been referred to Lower Greensand and not Lower Oolite.

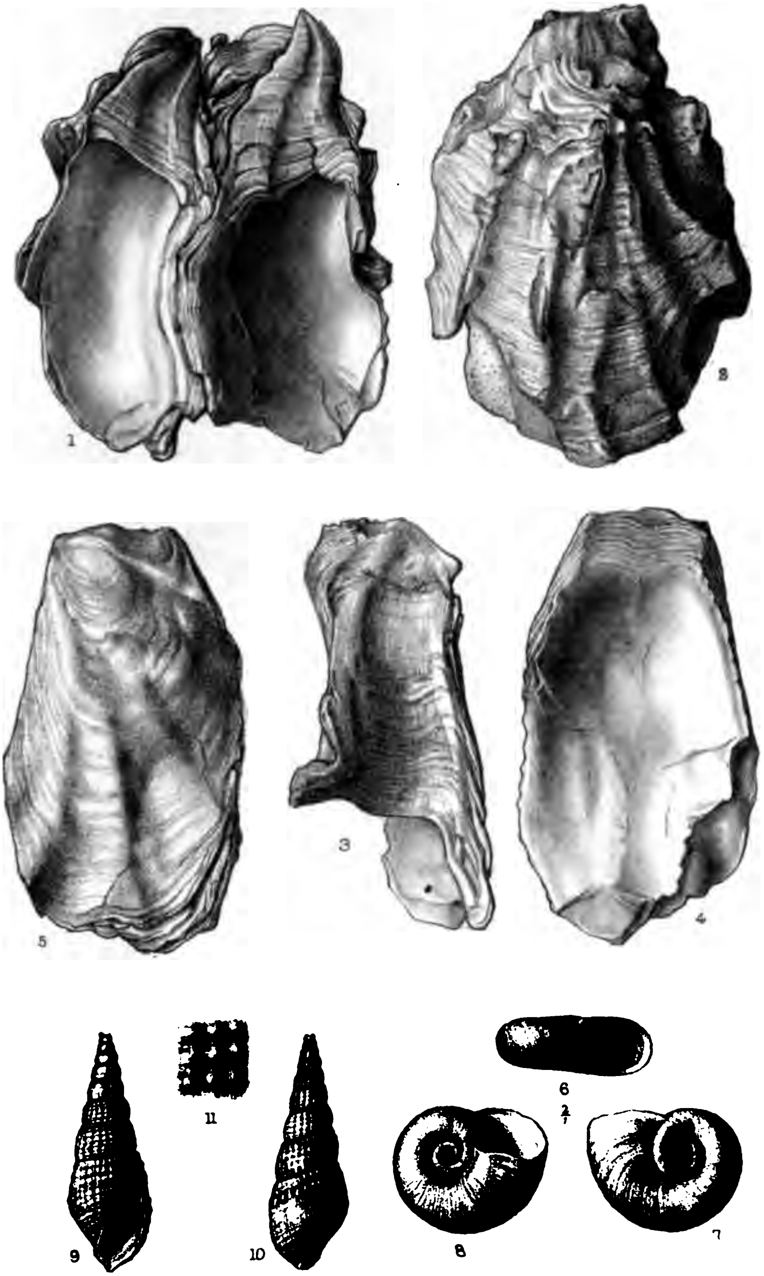
Chapter xiv contains an account of water-bearing strata and water-supply, with some useful diagrams, and two that are far from intelligible (figs. 147 and 149). Here the stratigraphical information is too meagre to be of much practical use. The references to impounding reservoirs in chapter xv are again too meagre to be of service. The concluding chapter deals with soils, and there is an appendix entitled "Simple rough methods for the determination of minerals and rocks." It would be well, as the author suggests, that the enquirer commences "by experimenting with known specimens."

CORRESPONDENCE.

GEOLOGICAL TIME.

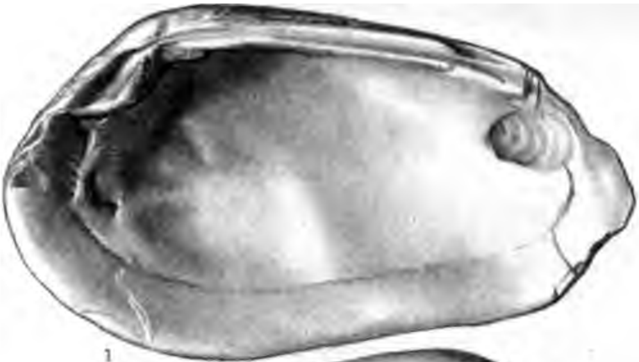
Sir,—All geologists will thank Sir A. Geikie for his admirable address to Section C at Dover this year. May I add another sentence bearing on "geological time," from Huxley's address in February, 1869 (Q.J.G.S., vol. xxv, p. l). He writes: "Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data."—F. G. S.

Turnham Green.



G. M. Woodward del. et lith. West, Newman imp.

Egyptian Pliocene and Post-Pliocene Shells.



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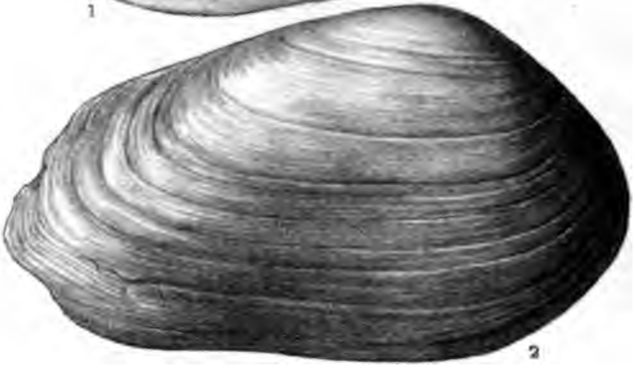

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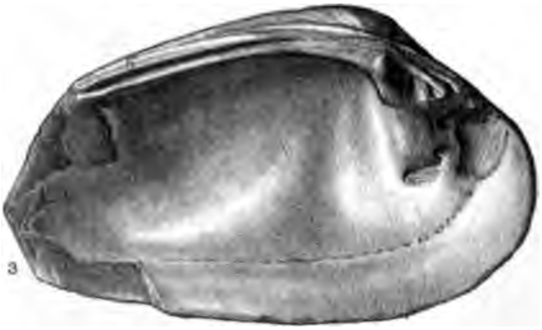

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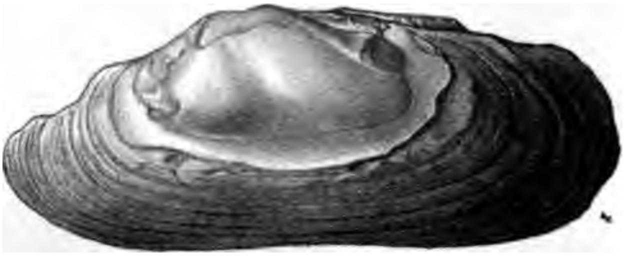

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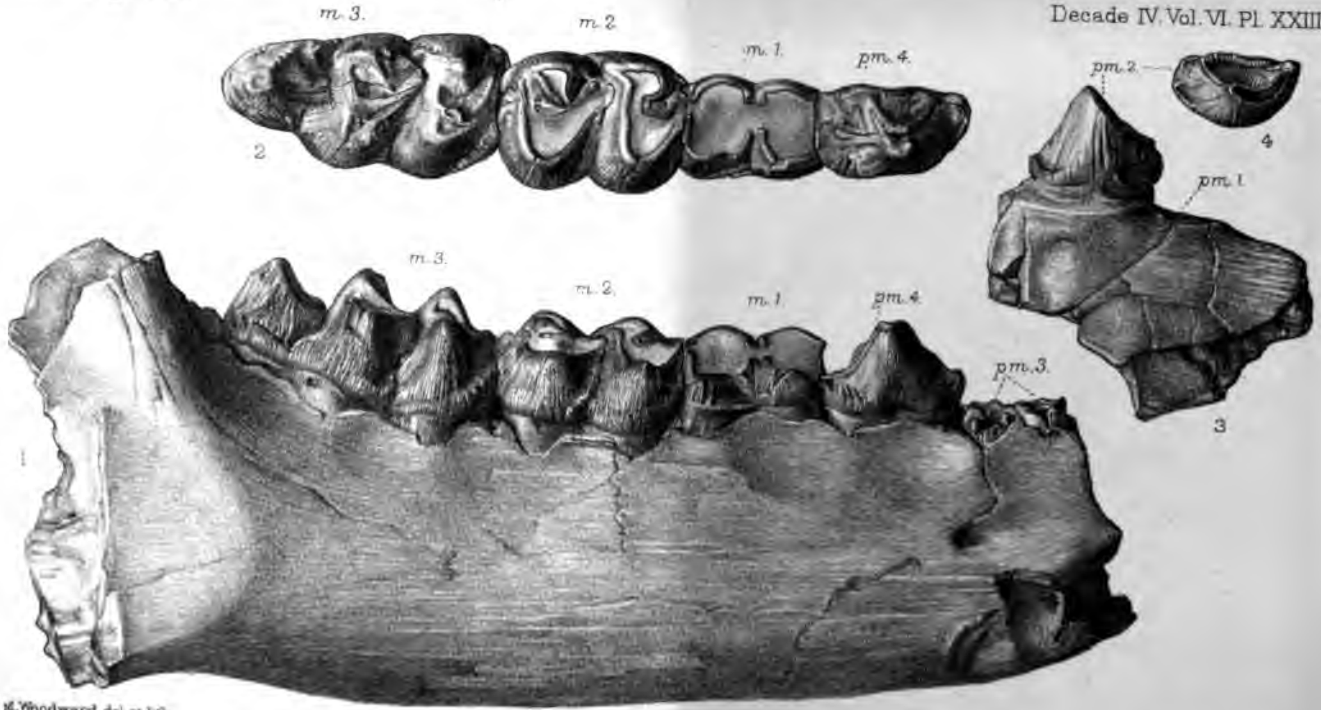
G.M.Woodward del et lith. West, Newman

Egyptian Post-Pliocene Shells.



G. M. Woodward del. et lith.

Brachyodus africanus, *sp. nov.* Lower Miocene, Egypt.

West, Newman imp.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. XI.—NOVEMBER, 1899.

ORIGINAL ARTICLES.

I.—Fossil Mammalia from Egypt.

By Chas. W. Andrews, B.Sc., F.G.S., British Museum (Nat. Hist.).

(PLATE XXIII.)

A CONSIDERABLE collection of mammalian bones obtained by the officers of the Egyptian Geological Survey, and sent to England by Captain H. Lyons for determination, proves to contain a number of specimens of great interest. The remains unfortunately are, for the most part, very fragmentary and in many cases quite indeterminable, but they are still sufficient to indicate the existence in Northern Egypt of several distinct mammalian faunas, the oldest being of Lower Miocene age, the most recent probably late Pleistocene and including species now living in the Nile Valley. As far as I am aware, the occurrence of Lower Miocene land mammals in Africa has not been recorded before, and it is to be hoped that continued search may lead to further discoveries, which cannot fail to throw much light on some obscure questions of geographical distribution.

In describing the specimens received hitherto it will be convenient to begin with the older forms and then pass on to the later.

Mammals from the Lower Miocene (*Burdighalien*).

The principal locality in which mammalian remains of this age have been obtained is Moghara, which lies in the desert rather more than a hundred miles nearly due west of Cairo. Most of the specimens were collected by Dr. M. Blanckenhorn, who, in a letter accompanying the specimens, has given a brief description of the deposits in which they were found. From this it appears that the beds form a series of alternating marine, fluviatile, and lacustrine deposits, some 200 metres thick; there is much sand and gravel, containing great silicified tree trunks as well as the remains of mammals and reptiles. Above or intercalated in these deposits, there is a bed of ochreous sandy marl containing characteristic Lower Miocene Echinoids and Molluscs. There are also some beds of *Hydrobia* limestone.

The occurrence of such deposits indicates the proximity of the shore-line of the Mediterranean as it existed previous to the Helvetian overlap. Rocks of the same character and containing a similar mammalian fauna occur in France (Sables de l'Orléanais), in Switzerland, and near Eggenburg in Austria, and may be regarded as contemporaneous deposits near the northern shore of the same sea.

Brachyodus africanus, sp.n.

The most important of the specimens from this horizon is an imperfect right ramus of the mandible (No. 2,849) of a large anthracotheroid ungulate (see Plate XXIII). The region in front of pm. 3 is wanting, and posteriorly the bone has been broken across 3 or 4 cm. behind the last molar, so that the articulation and angle are lost, and only the base of the coronoid process is preserved; it cannot be determined whether the angle was produced downward into a flange projecting below the level of the ramus, or not. The molars and last premolar are in an excellent state of preservation, but pm. 3 is represented only by its fangs implanted in their alveoli. The condition both of this specimen and of others from the same locality is such as to indicate that careful excavations would probably lead to the discovery of very well-preserved mammalian remains. The mandible in question was collected by Dr. Blanckenhorn, who pointed out that it probably indicated a new species of Depéret's genus *Brachyodus*, for which he proposed the name *B. africanus*, a suggestion which is here adopted. The genus *Brachyodus* was founded by Depéret[1] for the reception of certain species of anthracotheroid ungulates which had hitherto been referred to ***Anthracotherium***[2] or *Ancodus*.[3] He takes *Anthracotherium onoideum* of Gervais[2] as the type of the genus, and describes a well-preserved mandible, together with some upper teeth and a calcaneum of this species from the Lower Miocene of Eggenburg.

As far as the mandible is concerned, the chief points in which, according to Depéret, *Brachyodus* differs from *Anthracotherium*, are: (1) The mandibular ramus in the region of the cheek-teeth is not so deep, its lower border is curved instead of nearly straight, the symphysis is less prolonged backwards and must have been less elongated, and there is only one dental foramen instead of two or three. (2) The lower molars are arranged in a continuous series, there being no diastema between pm. 1 and pm. 2, and at the same time these premolars are shortened in correlation with the shortening of the mandible. (3) In the lower molar teeth the inner tubercles are higher and less massive. The outer tubercles are more compressed in a V-shape; the postero-external tubercle unites by its anterior end with the postero-internal tubercle, as in *Ancodus*. The talon of m. 3 is less developed, and bears a single tubercle only, instead of two of about the same height. (4) The presence of a thick, unbroken ridge of enamel (cingulum) which surrounds the base of the cheek-teeth, particularly the upper molars; this ridge is scarcely indicated in *Anthracotherium*. (5) The presence of a peculiar sculpturing of the surface of the enamel into fine wavy ridges.

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[1] Depéret, "Ueber die Fauna von Miocänen Wirbelthieren aus der ersten Mediterranstufe von Eggenburg": Sitz. k. Akad. Wiss. Wien, Bd. civ (1895), p. 397.

[2] Gervais: Zool. et Pal. franç., 1e éd., t. i, p. 96; 2e éd., p. 190.

[3] Neumayr, "*Hyopotamus*-reste von Eggenburg": Verh. Geol. Reichsanstalt, *1883, p.* 283.

The following characters of the mandible and lower teeth are mentioned by Depéret as distinguishing *Brachyodus* from *Ancodus*: (1) The jaw of *Brachyodus* is less elongate anteriorly, there is no diastema between pm. 1 and pm. 2, and the crowns of the teeth are more brachyodont; (2) the lower cheek-teeth of *Ancodus* have no cingulum, and the enamel is not sculptured. On the other hand, according to this writer, there is great similarity between *Brachyodus* and *Ancodus*, both in the form of the mandibular ramus and in the structure of the lower molars. This diagnosis is largely founded on the specimen from Eggenburg, excellent photographic figures of which are given in the above-mentioned paper.

Certain points in the comparisons of these types just quoted seem open to objection. For instance, in specimens of the teeth, both of *Anthracotherium* and *Ancodus*, in the British Museum (Natural History), the enamel is sculptured, and some teeth of *Ancodus* approach those of *Brachyodus* very nearly in this respect. Again, judging from Depéret's figure, the cingulum is very slightly developed in the lower molars, particularly on the inner side; this is also the case in our specimen. In the description of the lower molars the following sentence—"der rückwärtig äussere Hügel heftet sich mit seinem vorderem Rande an den entsprechenden inneren Hügel wie bei *Ancodus*, und nicht mit seinem rückwärtigen Rande;"—is obscure, but it seems to imply that the anterior horn of the postero-external crescent (hypoconid) unites with the postero-internal tubercle (entoconid), as in *Ancodus*, and does not extend across the valley to the antero-internal cusp (metaconid); in the photograph of the Eggenburg specimen it can be seen that this is not so, the arrangement being like that shown on the accompanying Plate XXIII, Fig. 2. Some very worn molars of *Ancodus* show traces of a similar arrangement, which is the normal one in the molars of *Anthracotherium*.

The specimen now figured agrees in all important characters with that from Eggenburg, and must be referred to the same genus. It, however, belonged to a rather smaller animal, in which the crowns of the molars are longer in proportion to their width than in *B. onoideus*, and the dental foramen is smaller and situated beneath the anterior edge of pm. 4, instead of beneath pm. 1, differences which justify its specific separation suggested by Dr. Blanckenhorn. The length of the fragment is 21 cm.

In m. 3 the cingulum is fairly prominent on the antero-external angle of the tooth and on the outer side of the talon; on the inner side it is wanting entirely, except for a short distance on the inner side of the talon. The talon is large, and consists of a single crescentic cusp, similar to the outer cusps of the anterior portion of the tooth, but with the opening of the V looking forward and inwards instead of inwards only The outer limb of the V runs to the base of the internal cusp of the pair in front (entoconid), while the inner limb forms the inner border of the talon; between the arms of the V is a rudimentary cusp, which is wanting or scarcely perceptible in *Ancodus*, but which in *Anthracotherium* is large, and in fact equal to the V-shaped outer cusp and standing in the same transverse line with it; indeed, in the form of the talon *Brachyodus* is intermediate between the older genera. The structure of the other molars will be seen in the figure (Fig. 2); it is closely similar to that of the molars of *B. onoideus*. The fourth premolar is a very massive tooth, with one high cusp, from which radiate three ridges; one, running to the antero-internal angle, the second to a point a little behind the middle point of the tooth, while the third runs directly backwards, and terminates in a much worn tubercle on the prominent heel of the tooth; the cingulum is well developed on the anterior and posterior ends, and also on the anterior half of the inner side. Pm. 3 in this specimen is represented only by its two fangs imbedded in their alveoli; anterior to this the jaw is broken away.

The arrangement of the anterior premolars is shown in two other specimens, one of which is figured (Pl. XXIII, Figs. 3, 4). In this the second premolar is still in position; it has two roots, and its form is shown in Figs. 3 and 4. Immediately in front of it is the alveolus of the single-rooted first premolar. In front of this the upper border of the jaw was thin and sharp-edged; it is broken away about 20 mm. in front of pm. 1; no trace of the socket of the canine is visible, and from the form of the mandible it is improbable that this tooth was developed into a large tusk. The dimensions of the teeth are:—

	Length.	Greatest width.
m. 3	51 mm.	25 mm.
m. 2	36 ,,	24 ,,
m. 1	25 ,,	17 ,,
pm. 4	27 ,,	17 ,,
pm. 3	? ,,	? ,,
pm. 2	22 ,,	13 ,,

The wide distribution of this Lower Miocene Anthracothere is notable, and I think that probably, as Depéret has suggested, the Siwalik forms *Hyopotamus giganteus* and *Anthracotherium hyopotamoides*, described by Lydekker, belong to this genus also.

EXPLANATION OF PLATE XXIII.

Fig. 1.—Imperfect right ramus of mandible of *Brachyodus africanus* (No. 2,849, type-specimen).
,, 2.—Teeth of above specimen, seen from above.
,, 3.—Fragment of anterior of right ramus of mandible of another individual.
,, 4.—Second premolar, seen from above.

All the figures are rather more than ⅔ natural size.

(*To be continued.*)

II.—NOTES ON SUBAËRIAL EROSION IN THE ISLE OF SKYE.

By ALFRED HARKER, M.A., F.G.S., of H.M. Geological Survey of Scotland.
(Communicated by permission of the Director-General.)

CONSIDERING the prime importance attaching to the subject in almost every branch of geological inquiry, it is not a little remarkable that so little has hitherto been done towards obtaining precise measures of the actual waste of land-surfaces and comparing the rates at which the agents of destruction operate at the present time in different districts. Arrangements have indeed been made during recent years to observe systematically the results of marine erosion on our coast-lines, but concerning the far more important subject of subaërial erosion we have exceedingly few accurate data. Sir Archibald Geikie, in his recent address to the Geological Section of the British Association at Dover, has called attention to one aspect of the question, viz., as it affects estimates of geological time, and has urged the desirability of accumulating observations, which should be, so far as the conditions of the problem permit, of a quantitative kind. The few remarks which follow are based on notes made during four or five years' work on the Geological Survey of the central part of Skye, and it is perhaps hardly necessary to point out that the conclusions arrived at are limited to the same area. Indeed, if such observations are to have any value, it must be by comparison with observations made on similar lines in other districts.

Central Skye is a district of sufficiently varied physical characters. Mountains over three thousand feet high rise within two or three miles of the sea. These, with their subsidiary branches, embrace extensive corries, drained by streams which have a high gradient, and become in flood-time formidable torrents. Beyond the mountain-tract are deeply eroded basaltic plateaux, rising in places to 1,500 feet or more above sea-level. The rainfall is probably the heaviest in Britain, or indeed in Europe, amounting to as much as 100 or even 150 inches at sea-level, and doubtless much more among the mountains, while the district is swept during the greater part of the year by winds which often rise to severe gales of several days' duration. A newcomer to such a district might well expect to find decisive evidence of the continued activity of eroding and transporting agencies, but such expectation, as I shall show, would not be realized.

Skye, in common with the other islands of the Inner Hebrides, has often been cited as a striking example of the visible results of subaërial erosion, and it would be difficult to find in the British Isles a district more instructive in this respect. Lava-flows of Eocene age present their truncated edges on the hill-sides to a total thickness of thousands of feet. The gabbro and granite are of later date than the lavas; yet these plutonic rocks, consolidated doubtless under a thick covering of the basaltic lavas, now form the highest ground in the district. My thesis is that the vast amount of erosion thus attested is almost wholly referable to middle and later Tertiary times, the remaining and final touches being added by the ice and frost of the Glacial period. Under existing conditions the processes of degradation are practically at a standstill, and the total result of subaërial erosion since the disappearance of the glaciers has scarcely left its mark even on the minor details of the surface-features.

There is, of course, no anomaly in this, if we view it in connection with the principle that the efficiency of the agents of erosion is necessarily controlled by movements of upheaval and depression in the area concerned, an aspect of the question which has too often been neglected by geologists on this side of the Atlantic. Although the latest movement of land relatively to sea, of which we have direct evidence in the district, is one of elevation to the extent of about 100 feet, it cannot be doubted that the land-sculpture which gave the district its existing mountain and valley system was effected at a time when the country stood at a considerably higher level than at present. Desiring rather to record observations of fact than to enter into theoretical discussions, I will not pursue this subject. There is, however, one general question upon which I feel constrained to make a few remarks, viz., the share of ice-erosion in producing the existing surface-relief.

The writings of some geologists during recent years show a tendency to depreciate the importance of ice as an eroding agent. How this attitude is to be justified on *a priori* grounds it is not easy to understand. A pebble or a sand-grain held firmly in the grip of a glacier must certainly be a more efficient graving-tool than one rolled along the bed of a river, and the disparity in the same sense becomes more evident when we take into account the great pressure which must exist at every point of contact beneath a great thickness of ice. We shall not, however, assign to ice-erosion its due part in the total results produced unless we recognize that its effects differ to a great extent *in kind* from those of water-erosion. Some of these peculiarities I have specified in a recent number of this Magazine (May, 1899, pp. 196–9) without attempting to discuss their *rationale*. But, although a complete analytical treatment of the subject would be difficult, it is easy to see that the peculiarities in question connect themselves readily with the

FIG. I.

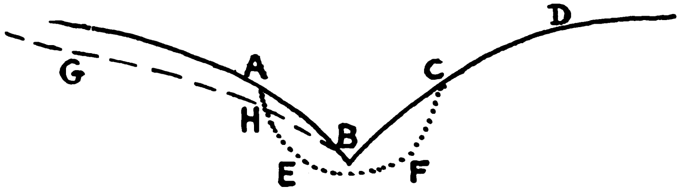

Fig. 1.—Transverse section of valley: ABCD initially, AEFC after modification by glacial erosion. Longitudinal profile of tributary glen: GHB initially, GHE after modification.

distinctive characteristics of ice-drainage as contrasted with water-drainage. Thus, a glacier occupies the whole width of its valley, while a river and its tributaries mostly follow narrow and defined paths: hence the peculiar U-shape of the glaciated valley and the precipitous descent by which a tributary glen joins the main valley (Fig. 1). Again, the amphitheatre form of the head of a glaciated valley connects itself with the fact that, while erosion near the sources of a river is very feeble, a glacier, on the other hand, springs into being, like Athene, fully armed. The dependence of glacial erosion upon the pressure, and so upon the thickness of the ice at any point, seems to offer an explanation of other characteristic features, such as the exaggeration of slight inequalities of gradient in a valley into precipitous drops (Fig. 2) and the excavation of small rock-basins.

FIG. 2.

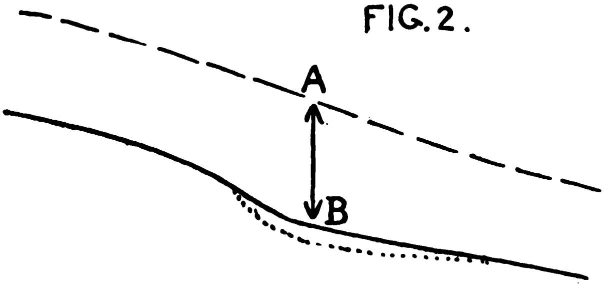

Fig. 2.—Longitudinal profile of valley occupied by glacier. Owing to inequality of gradient, the thickness of the ice at AB is greater than either above or below that place. The consequent more rapid erosion at B has the effect of exaggerating the inequality.

As distinguished from the erosion due directly to ice action, we have to note further the disintegration caused by frost in the later stages of the Glacial period. Nothing in the scenery of the Cuillins is more striking than the sharp contrast of the splintered and jagged summit-ridges with the rounded and polished surfaces of the corries and the lesser heights. The first impression is that the higher peaks have stood out above the ice, and so escaped the moulding and smoothing which have left their impress on the lower slopes; but in attempting to follow out this idea in detail many difficulties are encountered. Moreover, the movements of the ice, as traced out in the course of a complete survey, and the history of the glaciation of the district as a whole, almost compel us to the conclusion that, at the stage of maximum glaciation, the whole district was covered, even to the highest summits. Later, when the ice was reduced to gradually shrinking valley glaciers, the uncovered summit-ridges would be subjected during a long time to conditions highly favourable to the shattering and splintering of which they give evidence. In no other way can we account for the huge talus, often composed of large unworn blocks, which chokes the upper part of so many of the mountain valleys, being specially well displayed in the southern branch of *Coireachan Ruadha* and along the whole extent (a mile in length) of Garbh-choire. In their situation and condition these coarse screes often differ markedly from true stone-falls or from the waste of an escarpment in more ordinary circumstances. Some of the blocks have evidently fallen upon some soft cushion, such as snow; others could not reach their actual position by merely falling and rolling; others, again, have been derived from the rock upon which they rest. Screes of this kind must be regarded as, in a sense, Glacial accumulations, and, indeed, it is sometimes impossible to separate them in mapping from true ice-borne débris. The additions from later stone-falls are quite insignificant. What is true of the Cuillins, the gabbro mountains, seems to be true also of the Red Hills, formed of granite, though it is less easily demonstrated. The screes which conceal much of the slopes of these hills are not to be separated from the boulders which often cover the flat or gently rounded tops, and these are much more regularly distributed than, e.g., the blocks which build the tors of Dartmoor and other granite plateaux. Chemical, co-operating with mechanical, degradation has caused a sensibly greater post-Glacial waste of the general surface here than elsewhere in the district, but it is probably still of trivial amount, being measured by the slight projection of the occasional basalt dykes above the granite which they traverse.

Assigning, then, to the screes in general a Glacial age, it may be stated that post-Glacial erosion in the district is almost limited to the clearing out of the pre-Glacial channels by the removal of the boulder-clay which filled them. Not the valleys, but only the water-courses have been cleared, and these not always completely. On the lower ground, where the declivities are slight and the drift in places thick, streams seem in a few instances to have been diverted for some distance into a new course, but in no case is a new channel cut into rock. It will also be shown below that, when we speak of boulder-clay being removed, this is to be understood of the clay itself, not of the contained boulders. The courses of the minor streams in the drift-covered country are determined by the superficial features of the drift itself, which remain practically without change. Here and there a burn, winding its way among the tumulus-like mounds of the 'kettle moraine,' has trenched upon the steep slope of one of the mounds, but the smaller streams usually flow over turf or peat. The mountain torrents, which drain the bare rocks of the higher corries and fall in cascades over their rocky barriers, give even less indication of post-Glacial erosion. Sometimes they are guided by dyke-fissures, but as a rule there is no channel at all: the water glides over the polished rocks in a spreading sheet, through which the glacial scorings appear as distinct as elsewhere on the smooth surface. As might be inferred, the streams throughout the district are found to be wholly free from sand or other detritus.

Two localities in the district are worthy of special notice as illustrating the foregoing remarks. One is Eas Mòr, the most considerable waterfall in the Cuillins, on the lower part of the burn draining Coire na Banachdich. Here the burn plunges over a nearly vertical precipice of 140 feet into a steep-sided winding gorge, which continues for some 300 yards. The fall is caused by an irregular sheet of a fine-grained gabbro, more durable than the prevalent coarse type in the neighbourhood, and the gorge, at least as regards its upper part, results from the cutting back of the fall. Here, if anywhere in the district, we should find evidence of active erosion at the present time, and one or two small stone-falls of evidently recent date at the upper end of the gorge suggest at first glance that the cutting back may be going on rapidly. A closer examination, however, negatives this supposition, and proves that practically the whole of the gorge must have been cut out in pre-Glacial times. The boulder-clay by which it has been filled is for the most part cleared out from the bottom of the gorge, though some relics remain intact, the nearest being about thirty yards from the waterfall. The post-Glacial recession cannot, however, have amounted to anything like thirty yards, as appears from examining the rim of the gorge. The head of it is expanded into a relatively wide cauldron (itself a significant feature), and the drift is found to creep down the steep slopes of this cauldron in such a way as to leave little doubt that it has once been banked up against a face very nearly coincident with the present precipice of the waterfall.

The other locality alluded to is the Sligachan River, in the neighbourhood of the bridge, and its interest is with reference to the transport of material downstream. This river is one of the principal streams of the district, and is also liable to sudden floods in time of rain, rising sometimes five or six feet in a very short time. Like all the other streams, it is perfectly clear, even in the heaviest spates. The idlest lounger on the bridge cannot fail to remark that while the boulders in the bed of the river have dark blue and rusty brown colours (basalt and gabbro), those in the tributary stream on the right, which joins the river just below the bridge, are white or of pale tints (granite). Observing further that below the confluence the left bank of the river is dark and the right bank pale, he may perhaps conclude that the main river drains an area of dark rocks and the tributary burn an area in which the pale predominates. A little more examination, however, will compel him to abandon this explanation, for he will find that the pale boulders creep obliquely across the river until they occupy the whole of the bed, and the broad shingle-flats between and near tide-marks in the estuary below are composed essentially of white and yellow granite.

The key to the puzzle lies in the fact that here, as throughout the district, the boulders and gravel—coarse or fine—in the bed of a stream have no direct relation with the solid rocks of the drainage-basin, but depend solely on the constitution of the drift deposits in the immediate neighbourhood. Where there has been no drift, there are no pebbles in the burns. Where a burn has had to re-excavate a channel through the drift, it has done so by merely removing the finer material, the enclosed stones, large and small alike, remaining as boulders and gravel in the bed of the stream. They may have travelled downstream for a certain distance, but this distance is always small; in the particular instance selected it is capable of fairly accurate measurement, as follows. The upper part of Glen Sligachan has the Red Hills on the right and the Cuillins on the left. Accordingly we find that granite boulders largely preponderate in the drift on the right side of the valley and gabbro boulders on the left, and a sharp line of division can be drawn along the middle of the valley. Lower down, where the floor of the valley consists of basalt, this rock enters increasingly among the boulders; but the line can be traced to Sligachan and for some eight or nine miles beyond, affording important information concerning the course of the great Sligachan glacier. In the neighbourhood of Sligachan itself this line can be laid down with considerable precision, certainly within a very few yards. As shown by the broken line in Fig. 3, it crosses the river just below the bridge, and thence follows a westerly direction. The dotted line in the figure marks the corresponding division among the stones in

FIG. 3

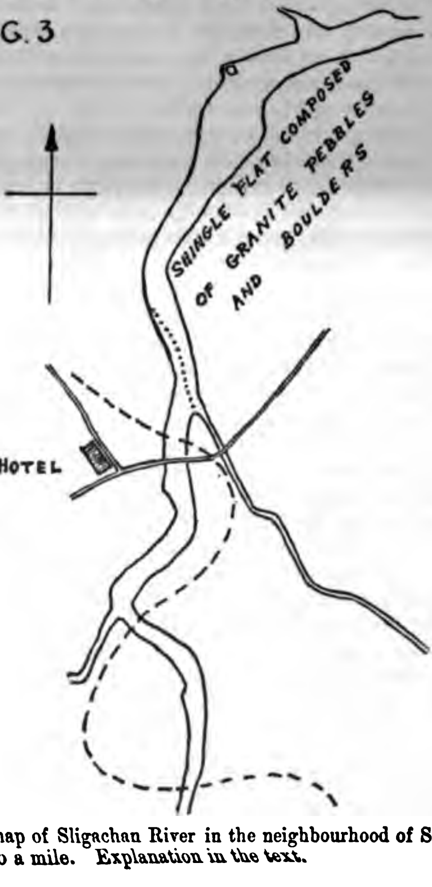

Fig. 3.—Sketch-map of Sligachan River in the neighbourhood of Sligachan; scale, six inches to a mile. Explanation in the text.

the bed of the river, granite largely predominating on the right and being almost wanting on the left. The distance between the two lines thus represents the total downstream movement during post-Glacial times. It is between eighty and ninety yards as measured along midstream, being less along the right bank and more along the left. No distinction has been made between small pebbles an inch in diameter and boulders a foot or more, so that the result obtained expresses the average amount of displacement of the whole collectively. Doubtless the small stones have travelled farther with the stream than the large, and indeed this appears clearly when we examine other places at which the same river crosses the dividing-line in the drift. There are six such places above Sligachan bridge, and at such of them as afford suitable conditions for observation a variable amount of downstream transport can be verified. It reaches nearly 250 yards in the extreme case, this being for fine gravel.

One remark is necessary to guard against misunderstanding. It is not asserted that a stream like the Sligachan River is not *competent* in times of flood to move even large boulders with ease; only that it does not do so to any important extent at the present time and under natural conditions. A state of equilibrium has been attained, in which the stones are so packed as to support one another and offer the greatest possible resistance to the stream. The displacement by any means of a keystone may cause movement among others adjacent to it, just as stepping-stones artificially placed may be swept away by a heavier spate than usual. The following observation is instructive in this connection. The positions of a number of boulders in the Sligachan River were noted by stretching a string from bank to bank and marking where the string fell upon each boulder. After a year and a half, examination showed that only one of the train had suffered any appreciable displacement, and this boulder, which had been moved (by sliding, not rolling) two feet or more downstream, was one of the largest in the neighbourhood, weighing probably not less than three-quarters of a ton. The circumstances left no reasonable doubt that its movement had been rendered possible by the artificial displacement of smaller stones which had served to protect and support it. Indeed, it may fairly be conjectured that the downstream displacement of eighty or ninety yards recorded near Sligachan bridge is mostly of comparatively late date, and is due in great part to disturbances consequent on the movements of anglers. A similar remark applies to loose screes among the mountains. I have observed no sliding of scree-material that was not directly due to sheep or to shepherds and other pedestrians, and it is probable that before the introduction of sheep during the present century there was no such sliding. To whatever class of phenomena we turn, we are led to the same conclusion, that in the district discussed the agents of atmospheric degradation, erosion, and transportation are at the present time almost wholly inoperative, and have accomplished only insignificant results during the whole of post-Glacial time.

III.—ON FOSSIL DORMICE.

By Dr. C. I. FORSYTH MAJOR, F.Z.S.

IN the nomenclature of fossil Myoxidæ, the generic term *Myoxus* has hitherto been used in a broad sense, under the assumption that the distinctive characters of the recent genera of the family are not apparent in their Tertiary representatives. It is my purpose to show in the present note that this is not the case, there being in the Middle Miocene, at any rate, two forms of Myoxidæ, one a *Muscardinus*, the other an *Eliomys*, which have been mixed up together by several previous writers, under the name *Myoxus Sansaniensis*.

1. MUSCARDINUS SANSANIENSIS (Lartet).

Myoxus Sansaniensis, Lartet: Notice Colline de Sansan, 1851, p. 20. P. Gervais: Zool. Pal. Fr., 2^{e} éd. (1859), p. 37, pl. xliv, figs. 14–19. Lydekker: Cat. Foss. Mamm. Brit. Mus., part i (1885), p. 224. H. Filhol: Ann. Sc. Géol., xxi (1891), 1, p. 39, pl. i, figs. 9, 10. ? Depéret: Arch. Mus. Lyon, v (1892), p. 51.

? *Myoxus niteloides*, Depéret: Arch. Mus. Lyon, iv (1887), p. 154, pl. xiii, figs. 15, 15*a*.

Myoxus Zitteli, Hofmann: Abh. k. k. Geol. Reichsanst., xv (1893), 6, p. 43, pl. iii, figs. 15, 16.

As regards the shape and relative proportions of its cheek-teeth, the recent *Muscardinus avellanarius*[1] is more specialized than either *Eliomys* or even *Glis* (*Myoxus*). The premolar is more reduced than in the latter two genera, owing to its being interfered with by the incisor;[2] apparently by way of compensation, the first true molar is increased in length. Moreover, the triturating surface of the molars of *Muscardinus* exhibits the shape of a rasp much more pronounced than in the above-mentioned two genera. This conformation is quite unique amongst mammalian teeth; the molars of *Elephas* have been compared with those of *Muscardinus*, but they are hypselodont in the extreme and exhibit on their crown an alternation of layers of enamel, dentine, and cementum, whereas those of the latter genus are probably the most brachyodont of all mammalian teeth.

We might expect that fossil members of the genus will show a more normal condition of their teeth than *Muscardinus avellanarius*; this is, in fact, in one respect realized in the left upper jaw of a dormouse, which more closely approaches to *Muscardinus* than to either *Eliomys* or *Glis*, and which I therefore consider as a species of the former genus. I collected it some years ago in the Middle

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[1] It is almost generally admitted that the genus is represented by only one recent species. However, the Italian *Muscardinus* rejoices in two specific names: *Myoxus speciosus*, Dehne, from Tursi in the Basilicata, Southern Italy (Allg. deutsche naturhist. Zeit., 1855, p. 180); and *Muscardinus pulcher*, Barrett-Hamilton, from Siena in Tuscany, Central Italy (Ann. Mag. Nat. Hist. (7), ii, 1898, p. 424). I have examined the skull and dentition of the type of *M. pulcher*, and cannot find the slightest difference from Northern specimens. On '*Myoxus speciosus*' see Blasius, Naturg. Säugeth. Deutschl., 1857, p. 298.

[2] Winge, "Om græske Pattedyr": Vidensk. Meddel. Naturh. Foren. Kjöbenhavn f. Aaret, 1881, p. 52 (1882).

Miocene locality of La Grive-Saint-Alban (Isère, France); it is at present preserved in the Geological Department of the British Museum (No. M 5.299). In this fossil the upper premolar, though already reduced in size, is less so than in the recent species, exhibiting four transverse ridges as against two in *M. avellanarius*. M. 1 is not rectangular, as in the latter, but quadrangular. The lengthening of this tooth in the recent species is not, as might have been expected, brought about by an increase in the number of enamel ridges—for there are five of them in *avellanarius*, seven in the fossil —but by a widening of the interspaces between the ridges. In the shape and pattern of m. 2 there is scarcely any difference between the two; *M. avellanarius* exhibits seven transverse ridges, the corresponding fossil tooth six complete and two abortive ridges. M. 3 is the smallest of the true molars in both species. In *M. avellanarius* there are six transverse ridges, more crowded together than in the anterior molars; the fossil tooth is not larger than the recent, but it contains no less than twelve exceedingly minute transverse ridges. Short intermediate ridges are present near the outer margin of all the true molars of the fossil. The length of the four cheek-teeth is 3¾ mm.

In the conformation of the premolar and in the reduced size of m. 1, the fossil form therefore approaches towards a more normal condition; it comes near *Glis*, which in its turn is intermediate between *Muscardinus* and *Eliomys*. But in the pattern of the molars, and more especially of m. 3, the Miocene species is still more specialized than the recent species of *Muscardinus*.

The remains from La Grive are by no means the only ones known of this species. Lartet has given the name *Myoxus Sansaniensis* to the smaller of two dormice from Sansan. His description, which I transcribe, is rather imperfect: "Petit Loir de la taille de notre Souris domestique. La couronne de ses molaires est plus compliquée de contours émailleux que celles du *Lérot* et du *Muscardin*, par quoi il se rapprocherait davantage du *Loir* proprement dit. . . . ."[1] However, from the characteristic figures published by Gervais,[2] and from some remains presented by Lartet to the British Museum (Natural History)—No. 33,274[3]—it can be seen that the Sansan dormouse is identical with the one from La Grive. Gervais' figures have met with severe but quite unfair criticism from more than one of the later writers on the subject, because these figures disagree with the teeth of another form of fossil dormouse hereafter to be described, which was wrongly held to be the species noticed by Lartet. Lydekker is quite right when stating that the Sansan specimens in the British Museum (Natural History) agree precisely with those figured by Gervais.[4]

The fragmentary remains from Sansan in the British Museum afford information with regard to the alveoli of the cheek-teeth, showing that the fossil species differs from the recent in the number of roots of the upper teeth. A small fragment of the upper jaw exhibits the alveolus of the premolar and that of the first true molar. The former shows that the upper premolar had three distinctly separate roots, like the first true molar, though minuter and more crowded together than in the latter. In both, two minute roots are situated externally, a larger one internally. This conformation of the roots of *Muscardinus Sansaniensis* is confirmed by an examination of the fossil jaw from La Grive, from which it further appears that the three roots of m. 2 and m. 3 are arranged in the same manner as in the anterior teeth.

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[1] Loc. cit.

[2] Zool. Pal. fr., pl. xliv, figs. 14–19.

[3] See Cat. Foss. Mamm. Brit. Mus., part i, p. 224.

[4] Lydekker, Cat. Foss. Mamm., part i, p. 224.

In *Muscardinus avellanarius* the upper premolar is one-rooted. The roots of the first true molar are described by Nehring as follows: "Der erste (langgestreckte) Molar besitzt fünf Wurzeln, deren Alveolen so gestellt sind, dass sie ein Trapez bilden; drei derselben liegen an der Gaumenseite (die mittlere ist sehr zart), die beiden andern finden sich an der Aussenseite des Kiefers." The second and third upper molar each exhibit four roots.[1]

The lower jaws from La Grive at my disposal are: (1) A right mandibular ramus (Geol. Dep., No. M 5,300), in which only m. 2 is preserved. Length of the alveoli of the four cheek-teeth 3¾ mm., as in the upper jaw from the same deposit. (2) A fragmentary right ramus, exhibiting the first and second true molars. Amongst the small fragments from Sansan in the Geological Department (No. 33,274) is (1) a mandibular fragment, right side, showing the empty alveolus of the premolar, and the first true molar; (2) a fragment of a right ramus, in which are preserved the first and second true molars. The general character of all these teeth is that of those of the upper jaw. Their crown is perfectly flat; the transverse ridges show no tendency to form tubercles at either the outer or the inner margin, although some of the crests join together on the outer and on the inner side. This occurs likewise in the recent *Muscardinus avellanarius*, but to a lesser extent than in the fossil. M. 1 is of slightly less size—shorter and narrower—than m. 2, and considerably shorter than m. 1 of *Muscardinus avellanarius*, also differs from it in the same manner as does the corresponding upper tooth of the fossil from that of the recent form. This tooth in the fossil is almost square; the posterior margin, however, is broader than the anterior. The number of transverse ridges is six in both the fossil teeth preserved (m. 1 and m. 2), besides some incomplete intermediate ridges situated near the inner side. In one m. 1 of La Grive, a much worn tooth, I observe only five complete ridges.

From the alveoli preserved, the number of roots can be made out as follows: one in the premolar, two in the true molars. In the recent species the lower premolar has likewise one root, m. 1 three roots, m. 2 four, m. 3 three.[2]

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[1] A. Nehring, "Zum Zahnsystem der Myoxinen": Zeitschr. Gesammt. Naturw., *1879*, p. 739.

[2] Nehring, loc. cit.

It seems probable that Depéret's *Myoxus niteloides* from La Grive-Saint-Alban[1] is likewise a synonym of our *Muscardinus Sansaniensis*, a view which Depéret himself advocates in his later publication[2] by uniting his species with *Myoxus Sansaniensis*, Lart., from Sansan. But neither the description nor the figures are sufficiently accurate to decide the matter.

Hofmann[3] has described two fragmentary lower molars from the Middle Miocene of Göriach and recognized them as belonging to *Muscardinus*. He proposes a new specific name, *M. Zitteli*, under the belief that they are a new form, but they belong undoubtedly to the species described by Lartet. The two molars are said to be from the left lower jaw; on p. 43 of the text they are referred to as m. 2 and m. 3, in the table of measurements of p. 44 and on the plate as m. 1 and m. 2. M. 1 (m. 2 of p. 43), at any rate the anterior one of the two according to the text and the plate, is incomplete on the outer side and slightly longer than the other (1·5 : 1·0 mm.). Taking into consideration that in the description of the teeth it is stated that their intermediate crests are near the inner side, it results from the inspection of the enlarged fig. 16 that the one marked m. 2 in the figure is in reality the anterior one, and therefore m. 1; the other, which is slightly longer and damaged on the outer side, marked m. 1, is the posterior of the two. This is on the assumption that the teeth are really from the left lower jaw, as seems most probable. As stated above, in a mandibular ramus from La Grive, m. 2 is slightly larger and also longer than m. 1. Hofmann's further description agrees with *Muscardinus Sansaniensis* from Sansan and La Grive.

2. ELIOMYS HAMADRYAS, sp.n.

Myoxus Sansaniensis, Schlosser: Palæontogr., vol. xxxi (1884), p. 97 (79), pl. vi (ii), fig. 46.

The assumption that all the Middle Miocene Myoxidæ are a single species, viz., the one from Sansan, called *Myoxus Sansaniensis* by Lartet, rests on the foregone but, as before stated, quite unjustifiable conclusion, that Gervais' figures of the latter form are inaccurate. Fraas, who was the first to assign this name to Myoxine remains from Steinheim,[4] gives no other reason for this identification. Since Steinheim has a considerable amount of mammalian species in common with Sansan and La Grive, it is quite possible that the small *Muscardinus* of the two latter localities may occur in the former also. But it is very difficult to understand what Fraas had before him, for his statement goes no further than to assert that his fossils from Steinheim belong to the Myoxidæ family: "Die Faltung des Kronenschmelzes ist die der lebenden Arten." From the dimensions given it would appear that part at least of the Steinheim Myoxidæ observed by him probably belong to a larger form than *Muscardinus Sansaniensis*. The roots of the lower cheek-teeth, as described by Fraas, agree with those of the species here described under the above heading.

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[1] Arch. Mus. Lyon, iv (1887), p. 164.

[2] Ib., v (1892), p. 51.

[3] A. Hofmann, "Die Fauna von Göriach": Abh. k. k. Geol. Reichsanst., xv (1893), 6, p. 43, pl. iii, figs. 15, 16.

[4] O. Fraas, "Die Fauna von Steinheim": Württemb. Naturw. Jahresh., xxvi (1870), p. 180.

Schlosser likewise unites the Steinheim species with "*Myoxus Sansaniensis*." But, otherwise, by a true conception of the pattern of Myoxine molars, he considerably improves on his predecessor's work, although provided with much scantier material from Steinheim. A good description and a fairly good figure of the lower molars are given.[1] They are described as exhibiting four transverse crests running completely across the triturating surface, whilst three minor crests, starting from the inner margin, terminate in the middle of the crown. In older specimens a partial fusion between two adjoining transversal crests may occur. The Steinheim species, according to Schlosser, shows affinities with *Glis* (*Myoxus*) as well as with *Eliomys*, sharing with the former the large number of transverse ridges; with the latter the concavity of the crown, surrounded by strongly raised margins.

Further on it will be shown that at La Grive-Saint-Alban the Myoxidæ are represented by a second form, larger than the *Muscardinus Sansaniensis* and otherwise different, belonging to the genus *Eliomys*, and identical with the lower molars described by Schlosser from Steinheim. Filhol was aware that the Steinheim species is distinct from '*Myoxus Sansaniensis*' of Sansan: ". . . . il m'a paru que l'espèce de Sansan était différente de celle de Steinheim, qui a été confondue avec elle."[2] Depéret follows Schlosser by mixing up both in the synonymy of '*Myoxus Sansaniensis*.'[3]

No upper jaws of this larger dormouse from La Grive are at my disposal. This is the more to be regretted as the only upper molars—from the Middle Miocene of the Hahnenberg, Ries—which presumably belong to this species are, according to Schlosser, from an old individual, so that the original pattern cannot be clearly made out; this is, in fact, confirmed by the published figure.[4]

I have found at La Grive two mandibular rami of the left side, at present in the Geological Department of the British Museum (M 5,298), which I hold to be identical with the species described by Schlosser from Steinheim. The mandibular angle is imperfect in both, but on one specimen it can clearly be seen that it was perforate. In one of the specimens only m. 1 is preserved, in the other m. 1 and m. 2, the former of the two being damaged on the inner side. The teeth preserved and the alveoli of those missing show that each of the true molars had three roots, two smaller anteriorly and a larger odd one posteriorly, close to the outer margin of the bone. The broken fragment of the premolar in the one specimen and the shape of its alveolus in the other, prove that the premolar had one root and was rectangular, longer than broad. The crowns of the molars are slightly concave. The unique m. 2 exhibits six transverse crests, two of which are incomplete. Three of the crests swell on the outer margin into three blunt cusps, separated by two indentations of the margin. The second and the fifth crest do not reach the inner side; the first and third, and the fourth and sixth, are united together on the inner side by the raised margin of the crown, leaving in the middle of this internal margin a small opening, which corresponds to the interspace between the third and the fourth crest.

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[1] Loc. cit., p. 97 (79), pl. vi (ii), fig. 46.
[2] Ann. Sc. Géol., xxi (1891), art. No. 1, p. 39.
[3] Arch. Mus. Lyon, v (1892), p. 51.
[4] Loc. cit., pl. vi (ii), fig. 48.

M. 1 is slightly longer than m. 2, and exhibits four cusps on the outer side, which in the one specimen are more distinctly separated from each other than in the other by three indentations. The specimen of m. 1, in which the inner side is completely preserved, shows this to be of the same conformation as the inner side of m. 2. In addition to the six transverse crests of m. 2, the unbroken m. 1 exhibits a mere trace of a supplementary ridge in the interspace between the first and the second crest; and besides, the third crest sends off a ramification into the interspace between the second and the third, near the inner margin.

The slight divergence between the above description and that given by Schlosser is certainly not indicative of two different species. I find variations of a similar kind in different specimens of recent species, as for instance *Eliomys nitedula*, where the minor ridges are sometimes reduced to almost imperceptible knobs. Similar variations of Myoxine teeth are registered in Reuvens' monograph of existing Myoxidæ.[1] For the same reason I do not attach any value to the slight divergences between my two specimens from La Grive, although they might seem to acquire some importance by the fact of being of different size as well. In the ramus with two molars preserved (M 5,298*a*), the alveoli of the four cheek-teeth have a length of 3¾ mm., in the other (M 5,298*b*) of 4½ mm.

As to the affinities with recent forms, Schlosser, when considering the Steinheim dormouse to be somewhat intermediate between *Glis* and *Eliomys*, seems to have taken into consideration only one species of the latter, *E. quercinus*. My view that the fossil is an *Eliomys* is supported by the following characters:—

(1) Perforation of the mandibular angle, whereby it agrees with both *Eliomys quercinus* and *E. nitedula*, but differs from *Glis*.

(2) Number and position of the roots.—As shown long ago by Nehring,[2] there is considerable difference between *Glis glis* and *Eliomys quercinus* in the alveoli of lower molars. "Each of the four teeth of *Glis glis* has two alveoli, situated one behind the other and not sharply separated in the anterior tooth. In *E. quercinus* the premolar has only one root, each of the three molars three, two of which are situated anteriorly, one by the side of the other, the third

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[1] C. L. Reuvens: "Die Myoxidæ oder Schläfer" (1870).

[2] Op. cit., p. 738.

one posteriorly, near the outer margin of the jaw."[1] From what has been stated before, it follows that the fossil agrees with *Eliomys quercinus* in the number and position of the roots.

(3) Concavity of the crown.—This feature has been already pointed out by Schlosser.

(4) Pattern of the cheek-teeth. — Schlosser remarks that, in opposition to *Eliomys*, the fossil shares with *Glis* the large number of transverse crests. However, the eastern species of *Eliomys*, *E. nitedula*, has quite as many as *Glis*, and in their arrangement agrees more with the fossil than does the last-named genus. In the latter the transverse crests are much more loosely, or not at all, connected by a raised internal margin, so that the triturating surface approaches the form of a rasp, a feature of the molars which is still more distinctly exhibited by *Muscardinus*.

By the specific name *E. Hamadryas*, which I propose for the fossil from Steinheim and La Grive—taking M 5,298*b* from La Grive as the type of the species—I wish to recall its affinity with the recent *Eliomys nitedula*, Pall. (*E. Dryas*, Schreb.). It is distinguished from the latter by superior size and by m. 1 being larger than m. 2, while the reverse is the case in the recent species.

The supposed second species of dormouse from Sansan cannot be seriously considered, because it has not been described; and from the way in which Lartet mentions it, it appears that he entertained doubts about its affinities: "*Myoxus*?? *incertus*.—D'après quelques dents molaires et des os des extrémités annonçant une autre espèce de *Loir* plus grand que le Lérot."[2] *E. Hamadryas* is smaller than *E. quercinus*, whilst this problematic fossil is said to be larger.

It only remains to compare *E. Hamadryas* with the Lower Miocene dormice; but I have scarcely any material for comparison, and, besides, the two horizons have not to my knowledge a single mammalian species in common. Of the three mandibles which are noticed in the Catalogue of Fossil Mammalia in the British Museum[3] under the heading *Myoxus murinus*, Pomel, only No. 31,118, from the Lower Miocene of the Allier (Bravard Collection), is a dormouse. The two others, No. M 1,629, from the Upper Eocene of Caylux, France, as well as No. 34,904, from the Lower Miocene of Puy-de-Dôme, France, belong to the genus *Eomys*, which has been placed by Winge into the family Dipodidæ.[4] The supposed close agreement between the cheek-teeth of M 1,629 and Filhol's figures of '*Myoxus murinus*' only exists so far as the dimensions are concerned.

Of the cheek-teeth only the first true molar is preserved in the right mandibular ramus from Allier (No. 31,118); it shows that

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[1] *E. nitedula* has been sometimes considered to be a species of *Glis*. Besides the agreements with *E. quercinus* pointed out in the text, the upper molars of *E. nitedula* likewise decidedly favour the same view, as has been shown by Winge: Vidensk. Medd. Naturh. For. Kjöbenhavn f. Aaret, 1881, pp. 51, 52 (1882).

[2] Op cit., p. 20.

[3] Part i (1885), pp. 224–5.

[4] H Winge, "Jordfundne og nulevende Gnavere, etc.": E Museo Lundii, I, *iii* (1887), pp. 118, 166.

Pomel's description of the molars of '*Myoxus murinus*' is quite correct: "Les molaires ont une forme de couronne plus compliquée que celle du lérot, auxquelles elles ressemblent le plus."[1] We have here, again, the pattern of the *Eliomys* molar, approaching close to *E. Hamadryas*. There are four complete crests, alternating with three rudimentary ones; besides, three tubercles on the outer margin. In addition to the usual indentation in the middle of the raised inner margin, there is a slight indentation on its anterior half as well; and this is about the only difference from *E. Hamadryas* in the pattern of the tooth.

The alveoli of the true molars, however, differ considerably, and show that the lower molars of *Eliomys Pomeli*, Trouess. (= *E. murinus*, Pom.), had each only two roots. The premolar was one-rooted.

In size, m. 1 of *E. Pomeli* is slightly inferior to the corresponding tooth of *E. Hamadryas*, although the length of the whole lower dental series is about the same as in the smaller specimen of the latter species (3½ mm.).

I conclude the present note by a few remarks on the Pleistocene *Leithia* and on the affinities of Dormice generally.

Mr. Lydekker[2] has proposed a new genus, *Leithia*, for the Pleistocene 'Giant Dormouse' of Malta. He is quite positive in asserting that this fossil does not belong to the Myoxidæ, nor to the 'Myomorpha,' and he inclines to constitute for this genus a separate family (Leithiidæ) of 'specialized Sciuromorpha.' His reasons are twofold:—

(1) The infraorbital foramina are said to be of very minute proportions, thus resembling what obtains in squirrels. This I venture to deny, for it is quite evident that the slit-like appearance of the infraorbital foramen in some of the skulls is due to their crushed condition; in one which is a more normal cranium, the foramen is of considerable size.

(2) The upper cheek-teeth are said to resemble those of Sciuridæ, and are said to be nearest to *Xerus* and *Pteromys*; therefore "it seems not impossible that both types of teeth might be derived from a common stock." With this last proposition I quite agree. It is, however, well known that the same may be said, and with greater truth, of the Myoxine *Eliomys*, the four upper cheek-teeth of which "agree in the main with the corresponding teeth of *Sciurus vulgaris*"[3]—indeed, more so than the teeth of *Leithia* agree with those either of *Xerus* or *Pteromys*.

If no other choice was left save to class *Leithia* and the Myoxidæ with either the 'Myomorpha' or the 'Sciuromorpha,' then, taking the Muridæ to be the type family of the former and the Sciuridæ the type of the latter, they would have to be ranged with the latter, which in its essential characters as a family shows a more primitive conformation.

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[1] Pomel: Catal. Méth. et Descr. des Vert. foss., etc., 1853, p. 24.

[2] R. Lydekker, "On the Affinities of the so-called Extinct Giant Dormouse of Malta": Proc. Zool. Soc. London, 1895, p. 860.

[3] H. Winge, "Om græske Pattedyr": loc. cit., p. 51.

Whilst it seems to me perfectly justifiable to create a separate genus for the Malta fossil, I fail to see any stringent necessity for removing it from the Dormice, with which, as far as our present knowledge goes, it agrees best in the cranial and dental characters, as well as in the conformation of the limbs. The only other group which comes in question is the Anomaluridæ of Winge. But this remark applies equally to the Myoxidæ generally, as was long ago recognized by Waterhouse, followed by Gervais. Both these zoologists gave proof of remarkable perspicacity, the former in approximating *Anomalurus* to the Myoxidæ,[1] the latter in grouping *Anomalurus*, '*Myoxus*,' and the Tertiary Theridomyinæ in one family[2] Flower and Lydekker[3] place *Anomalurus* in the 'Sciuromorpha,' the Myoxidæ in the 'Myomorpha,' and the Theridomyidæ in the 'Hystricomorpha.'

In support of placing *Leithia* with the Anomaluridæ, instead of with the Myoxidæ, might be adduced, first, its molariform premolars, which are less reduced than even in *Eliomys* or *Glis*; and, secondly, the inner longitudinal 'wall' of its upper cheek-teeth, which is a peculiar feature of *Anomalurus*, but not of *unworn* Sciurine molars. These characters we have to weigh against the Myoxine distal union of the tibia and fibula in *Leithia*. Considering that already within Anomaluridæ occur reduced premolars,[4] and that the aforementioned conformation of the upper molars occurs, within Anomaluridæ, in the genus *Anomalurus* alone, we should best meet all the exigencies of the case by classing the whole of the Dormice, *Leithia* included, at the end of the Anomaluridæ as one of their sub-families, of equal rank with Winge's "Trechomyini, Anomalurini, Theridomyini, and Pedetini."[5] This is about the place assigned to the Dormice by Von Zittel,[6] who, however, constitutes for them and for Winge's Anomaluridæ, etc., a provisional sub-order, the Protrogomorpha, a course which has the advantages but also the defects inherent to compromises. And so has the other course followed in the Handbuch, viz., the retention of the terms *Sciuromorpha, Myomorpha*, etc., attaching to them, however, a rather different meaning from that intended by Brandt, who unfortunately is still followed by the majority of zoologists.

For at the bottom of the whole matter, and the cause of all the mischief, are the 'hard-and-fast' divisions into which the Rodent genera are up to the present day being forced. If we continue to cling to the 'time-honoured' but unnatural sub-orders *Sciuromorpha*,

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[1] Proc. Zool. Soc. London, 1842, p. 126.

[2] Zool. Pal. Fr., 2e éd. (1859), p. 27.

[3] "Introduction to the Study of Mammals," 1891, pp. 449, 459, 484.

[4] For example, in *Zenkerella* (*Aëthurus*). Cf. W. E. de Winton, "On a New Genus and Species of Rodents of the Family Anomaluridæ": Proc. Zool. Soc. London, 1898, p. 450.

[5] *H.* Winge, "Jordfundne og nulevende Gnavere": loc. cit., 1887, p. 118.

[6] "Handbuch der Palaeontologie," I, iv (1893), p. 526.

Myomorpha, and *Hystricomorpha* of Brandt, we cannot hope to gain an insight into the mutual affinities of the various groups of the order. These sub-orders are unnatural because (1) they ignore the fossil Rodentia and the lessons taught by them; (2) in some instances they present an amalgamation of heterogeneous groups; and (3) they draw barriers where in reality there are none. Winge, by pulling down these artificial barriers, has taken the bull by the horns, and we cannot do better than follow him.

IV.—On the South-Eastern Coalfield.[1]

By Professor W. Boyd Dawkins, M.A., F.R.S.

The discovery of a coalfield in 1890 at Dover, in a boring at the foot of Shakespeare Cliff, has been already brought before the British Association by the author at Cardiff in 1892, and is so well known that it is unnecessary to enter into details other than the following. The Carboniferous shales and sandstones contain twelve seams of coal, amounting to a total thickness of 23 feet 5 inches. These occur at a depth of 1,100 feet 6 inches below Ordnance datum, and have been penetrated to a depth of 1,064 feet 6 inches, or 2,177 feet 6 inches from the surface. They are identical, as I have shown elsewhere,[2] with the rich and valuable coalfields of Somersetshire on the west, and of France and Belgium on the east. The discovery is of great practical value, as it will probably result in the same development in Kent of industries and manufactures which has taken place where the coal has been worked, under the same conditions, beneath the Cretaceous and Jurassic rocks in France and Belgium. It is of equally great theoretical value, as it proves up to the hilt the truth of Godwin-Austen's view, published in 1858, that the Coal-measures lie buried underneath the newer rocks in South-Eastern England.

After the boring was completed in 1893 the discovery lay dormant until in 1897 the Kent Collieries Corporation began to sink shafts on the site of the boring, and to put down boreholes at Brabourne and Pluckley, in the Weald of Kent, to verify the range of the Coal-measures in the property which they held under lease.

The Mid-Kent Coal Syndicate also put down a boring at Penshurst, and the Kent Coal Exploration Company began work in various parts of eastern Kent. The borings of the two latter undertakings have been carried on under my supervision, and none of them, as yet, is completed. They, nevertheless, throw important light on the range of the Coal-measures in South-Eastern England, and are not unworthy of being brought before this meeting of the British Association.

The first boring to be noticed is at Ropersole, a spot near the highway between Dover and Canterbury—eight miles from Dover, at 400 feet above O.D.—the surface being composed of Upper Chalk, with a thin stratum of Clay-with-Flints. It was begun at the close of 1897, and has at the present time pierced the strata to a depth of 1,773 feet 7 inches.

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[1] A paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Proc. Royal Inst., June 6, 1890. Trans. Manchester Geol. Soc., xvii, Feb. 2, 1894; xxv, Feb. 9, 1897.

It is being carried out under the able superintendence of Mr. James Newton, resident engineer, with the calyx drill, and the occasional use of a diamond crown for the lower and harder rocks. The result in both cases is a solid core. The section is as follows:—

ROPERSOLE, 400 O.D.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
UPPER CRETACEOUS (953 feet)	Upper Chalk	480	0	480	0
	Middle Chalk	118	0	598	0
	Lower Grey Chalk ...	220	0	818	0
	Glauconitic Marl ...	16	0	834	0
	Gault	119	0	953	0
NEOCOMIAN (72 feet)	Lower Greensand ...	51	0	1,004	0
	Atherfield Clay	21	0	1,025	0
	Purbeck-Wealden Beds	55	0	1,080	0
OOLITIC (473 feet)	Kimmeridge Clay (?) ...	10	0	1,090	0
	Corallian	157	0	1,247	0
	Oxfordian, Callovian ...	142	0	1,389	0
	Bathonian	164	0	1,553	0
LIASSIC (27 ft. 9 in.)	Upper Lias	3	0	1,556	0
	Middle Lias...	24	9	1,580	9
COAL-MEASURES (192 ft. 10 in.)	Shales and Underclays	69	3	1,650	0
	First Coal	0	9	1,650	9
	Shales and Underclays	50	6	1,701	3
	Second Coal	0	6	1,701	9
	Shales and Underclays	22	3	1,724	0
	Micaceous Sandstones...	49	7	1,773	7

The Coal-measures contain the usual Carboniferous plants—*Sigillaria, Lepidodendron.* and ferns, and the usual Stigmarian roots and rootlets, and, like those which we struck in the borehole at Dover, are probably horizontal. The coal is bright and blazing, and breaks up into little cubes, but slightly deformed by pressure into the lozenge-shape. In this respect it agrees with the coals of Dover, and like them shows no sign of crushing. The horizontality of the beds in both these cases may be accounted for by the boreholes happening to strike the bottom of a Carboniferous synclinal fold. This conclusion, viewed in the light of the coalfields of France and Belgium, on the one hand, and of Somerset on the other, is more probable than the view that they extend horizontally over a very large area.

It is strengthened by the fact that the rocks, probably Devonian, struck at the bottom of the borehole at Brabourne, some few miles to the west, are inclined at a high angle. They here are a portion of an anticline which is probably related to the Coal-measures above them, as the Devonian axis of the Mendip Hills is related to the syncline of the Somerset Coalfield.

In my opinion the Coal-measures of Ropersole are a portion of the same series as those at Dover. Here, as at Dover, the question of seams of coal resolves itself probably into a question of sinking deeper. Here only two unimportant seams have been met with in a thickness of 192 feet. There twelve seams were penetrated in a thickness of 1,064 feet 6 inches, the thickest 4-feet seam being at the bottom.

The Ropersole boring establishes the fact that the Dover coal-measures extend northwards for a distance of eight miles and beyond in the direction of Canterbury.

It remains now to see how far the range of the South-Eastern Coalfield has been proved by other borings. None of the three others which are now being carried on by the Kent Coal Exploration Company at Ottinge, Hothfield, and Old Soar to the north of Tonbridge has been carried deep enough to give any evidence. We are, however, indebted to Mr. Etheridge[1] for conclusive proof that its south-western boundary does not extend as far to the south-west as Brabourne. Here a fine-grained grey argillaceous sandstone, in my opinion Devonian, was struck in a boring at a depth of 1,921 feet 5 inches from the surface, the strata being inclined at a high angle, and being covered by a red dolomitic conglomerate of Triassic age, just as similar rocks occur in the central axis of the Mendip Hills. This boring has verified the exact position of the Pembroke-Mendip anticlinal fold, which I mapped in 1894.[2] It ranges in a north-west and south-easterly direction close under the line of the Chalk downs from Folkestone to Wye, a few miles to the north of the theoretical line of my map, and forms the southern boundary of the South-Eastern Coalfield. In Somersetshire it emerges from beneath the Triassic and Jurassic strata in the Mendip Hills, and in Northern France along the low hills sweeping from Hardinghen past Ferques in the direction of Cape Gris Nez, where, as in the Mendip range, it is traversed by many faults.

The Coal-measures set in in Kent at a sufficient distance to the north-east of Brabourne to allow of the presence of the Carboniferous Limestone and Millstone Grit. These probably dip at the same high angle as the Devonian below. Their south-western boundary can only be accurately defined by further borings such as that which we are now carrying on at Ottinge, about two and a half miles to the north-east of the scarp of the Downs, and six miles to the south-west of Ropersole. Their range to the north and the east still remains to be proved. They are, however, continued under the Channel, and have been proved by the boring at Calais in 1850, as well as those carried out in 1898 at Strouannes near Wissant. In this district they are clearly shown by other borings to be faulted into the Devonian and other pre-Coal-measure rocks.

The thickness and value of this South-Eastern Coalfield can only be estimated by the exposed coalfields of Northern France and Belgium and of Somerset. That of Liége is 7,600 feet thick and contains eighty-five seams, presenting an aggregate thickness of 212 feet of workable coal. That of Mons is 9,400 feet, with 110 seams yielding 250 feet of coal. In Somersetshire the coalfield is 8,400 feet thick, the seams are fifty-five in number, and yield 120 feet of available coal. It is obvious from these figures that the possibilities of the South-Eastern Coalfield are very great, although it still remains to be proved how far these great thicknesses of rock have been denuded in Kent before the deposition of the Triassic and Jurassic rocks.

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[1] Brit. Assoc. Bristol Meeting, 1898.

[2] "The Probable Range of the Coal-measures in Southern England": Trans. Federated Institution of Mining Engineers, vol. vi, map.

The upper denuded surface of the South-Eastern field was struck at Ropersole at a depth of 1,180 feet 9 inches below Ordnance datum, and at Dover at 1,100 feet 6 inches. If the rocks which have to be traversed above O.D. be added the resulting figures of about 1,600 feet necessary to sink from the surface are well within the depth to which coal is now being worked at a profit in England and in France and Belgium. It is well within the 4,000 feet limit laid down by the Coal Commission of 1872.

The strata overlying the coal-measures at Ropersole and Dover present points of great geological interest bearing on the geographical conditions under which they were formed, as may be seen from the following table :—

Table of Comparative Thicknesses of Neocomian and Jurassic Rocks at Dover and Ropersole.

	Dover.		Ropersole.	
	ft.	in.	ft.	in.
Neocomian	124	8	72	0
Purbeck-Wealden	94	6	55	0
Oolitic	634	10	473	0
Liassic			27	9

All these rocks are thinning off to the northwards against the Carboniferous and pre-Carboniferous rocks, which form the 'axis of Artois' of Godwin-Austen, as he foresaw in 1858 that they must thin off in South-Eastern England. South and west of the meridian of Dover they thicken very rapidly, the Neocomians being 244 feet, the Purbeck-Wealden of Kent and Sussex being not much less than 2.000 feet thick, and the Jurassic rocks of considerable though unknown thickness. In the Netherfield boring, near Battle in the Hastings district, the Upper and Middle Oolites are proved to be more than 1,700 feet thick.

The evidence of the other boreholes under my supervision proves that the thickening of the Neocomian, Purbeck-Wealden, and Upper Jurassic strata to the south of the downs between Folkestone and Tonbridge is very considerable. It is summed up in the following table :—

	Ottinge.	Hothfield.	Old Soar.	Penshurst.
Neocomian	246	180+	? 50	—
Purbeck-Wealden	146	593	650	1,511
Portlandian	—	—	—	—
Kimmeridge Clay	—	--	—	356+

The Purbeck-Wealden beds also show a considerable thickening to the west, if the boring at Ottinge be compared with that of Penshurst, near Tonbridge, where the boring began low down in the Ashdown Sand, the lowest member but one of the group.

It remains for us to sum up the results of these borings, which are likely to effect the same economic revolution in Kent as was brought about in France by the extension of the coalfield of Valenciennes and Mons, about ninety-five miles to the west of its original outcrop at the surface, and to within some thirty miles of Calais. The coalfield has been proved at Dover. Its range for eight miles to the north has been also proved at Ropersole. Its southern boundary, as yet ill-defined, is marked by the Pembroke-Mendip anticline, ranging under the southern scarp of the chalk downs. Its range in other directions is unknown, and awaits further investigation. To the south of this anticline the Palæozoic floor is probably composed of pre-Coal-measure rocks. If, however, the Coal-measures do occur, they are buried under such great thicknesses of superincumbent rock—largely sands and loams full of water—that it will be difficult to work them. We know now by experiment not only where to seek, but also where it is advisable not to seek for the Coal-measures. The difficult problem of the buried Coal-measures in South-Eastern England, now being worked out by private enterprise, is likely to add greatly to the resources of this country, as it has already added to the wealth of geological knowledge.

V.—Some Recent Work among the Upper Carboniferous Rocks of North Staffordshire, and its bearing on Concealed Coalfields.[1]

By Walcot Gibson, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THERE is every reason to believe that in the near future the supplies of coal lying beneath the Red Rocks of the Midland counties will have to be relied upon to meet the increasing demand.

Workable seams of coal have been met with at reasonable depths beneath the Red Rocks surrounding the South Staffordshire Coalfield, but there remain large areas lying between the known coalfields of Shropshire, North Staffordshire, and Nottinghamshire, which have not at present been explored. Within this region, as shown on the published maps of the Geological Survey, there are considerable areas of so-called Permian rocks, which recent investigations have proved to be conformable to the Upper Coal-measures and to contain a Coal-measure flora. Thus Mr. T. C. Cantrill has shown that in the Forest of Wyre the so-called Permian rocks contain thin coal-seams and bands of *Spirorbis* limestone.[2]

Exceptional facilities afforded by numerous marl- and brick-pits and other artificial and natural exposures in North Staffordshire have enabled Mr. C. B. Wedd and myself to make out the following definite stratigraphical sequence in the Upper Carboniferous Rocks:—

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[1] A paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Quart. Journ. Geol. Soc., vol. li (1895), p. 528.

(4) *Keele Sandstone Series.*—Red sandstones and marls, calcareous breccias, fossiliferous (Entomostracan) limestones. Thickness, 700 feet, summit nowhere seen. (= Permian of older observers.)

(3) *Newcastle-under-Lyme Series.*—Grey sandstones, marls, and shales, with four thin coals. Two bands of fossiliferous limestone (Entomostracan) form the base. Thickness, 250 to 300 feet.

(2) *Etruria Marl Series.*—Red and mottled marls, with thin bands of coarse green grit near the summit and base. Thickness, 700 to 800 feet.

(1) *Black Band Series.*—Grey and mottled marls, the grey marl predominating; bands of ironstone with Entomostraca, *Anthracomya*, fish-remains; occasional bands of grit 30 feet thick; several thin coals; numerous zones of limestone and shales with Entomostraca. A band of limestone, constant in position (36 to 40 feet) above the Bassey Mine ironstone, forms the base. Thickness, about 250 feet.

Variability in the character of the deposits of the coal-measures is universal, so that it is hardly to be expected that this sequence will be recognizable in its entirety over the whole Midland area; but there can be no doubt that it is an important point to find out which of these divisions occurs at the surface in the areas at present regarded as Permian or as Upper Coal-measures on the published maps.

Already the determination of the successive divisions above noted has had important industrial bearings. The fact that the Newcastle limestone lies at the base of grey measures intercalated between an upper group of red strata (the Keele series) and a lower group of red strata (the Etruria marls) has enabled me to detect true Upper Coal-measures in Keele Park, Shutlanehead, and to the west of Leycett. Moreover, there seems to be little doubt that the Coal-measures of the Pottery Coalfield lie not far from the surface under Little Madeley and Craddocks Moss. Evidence has been obtained that the strata on the north-west side of the North Staffordshire anticline do not uninterruptedly descend beneath red rocks (so-called Permian) to the west of Leycett, but rise locally westward under Hayes. The effect of this change of inclination is to bring to the surface strata which lie considerably below the unproductive red series, and to bring the principal coals and ironstones within reach further west than might have been expected.[1]

It follows that a thorough and complete examination of the exposed coalfields of the Midland counties and of the bordering New Red rocks will be of the highest importance in determining at what depth the productive measures lie beneath the great central tracts of the Midland counties.

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[1] See Summary of Progress of the Geological Survey of the United Kingdom for 1898, p. 123.

VI.—NOTE UPON *PLIOHYRAX GRÆCUS* (GAUDR.) FROM SAMOS.

By C. I. FORSYTH MAJOR, M.D., F.Z.S.

A MUTILATED skull of an Ungulate from the Upper Miocene of Samos, purchased by the Geological Department of the British Museum in 1894, was in that year (before I left Europe) identified by me as a *Leptodon*, and under this name it was registered (M 5,419).

The types of *Leptodon græcus*, Gaudry, are two mandibular rami from Pikermi, known by the excellent description, accompanied by good figures, in the "Animaux fossiles et Géologie de l'Attique."

The generic identity of the remains from Pikermi and Samos respectively is shown by (1) the general character of the molar teeth, recalling the Palæotheres, Paloplotheres, etc., and among recent groups, more than all, the Procaviidæ (Hyraces), and (2) the special character of the last upper and lower molar. Moreover, the agreement in size entitles us to assign them to the same species :—

Length of lower true molars (m. 1 — m. 3) from Pikermi	95 mm.
Length of upper true molars (m. 1 — m. 3) from Samos	94 mm.

In both specimens, the true molars increase in size from before backward. In the lower jaw from Pikermi m. 3 is provided with a third lobe of unusual dimensions, while the corresponding tooth in the upper jaw of the Samos fossil exhibits also a considerable prolongation of its posterior part. This tooth, by its complication and great length as compared with m. 2 (43 : 25 mm.), presents a character very unusual amongst Ungulates, and for which we find analogies only among fossil Ungulates from Patagonia, more especially several of the Protypotheridæ, from which last I do not think that Ameghino's Archæohyracidæ need be separated. The prolongation of the palate backward beyond the molar series and the posterior position of the infraorbital foramen and orbit are further points of agreement between the fossil from Samos on the one side and the Patagonian Ungulates on the other. The teeth from Pikermi and Samos are rather brachyodont, those of the Protypotheridæ highly hypselodont or rootless; characters which, as matters at present stand, rather oppose the view of a South American origin of the Protypotheridæ.

A skull, also from Samos, in the Stuttgart Museum, described by Osborn in the Proceedings of last year's International Congress of Zoology under the name of *Pliohyrax Kruppii*, corresponds with the London skull in the elevated position of the orbit (which is complete, as shown by the latter fossil), in the extension of the bony palate backward beyond the molars, and in the structure of the molars. The anterior part of the skull, missing in the British Museum specimen, shows the relationship of *Pliohyrax* with *Hyrax* "in the enlarged pair of incisor teeth," which approach more nearly in form to those in female skulls of the recent genus.

In a recent notice by Schlosser (Zool. Anz., Sept. 18 and Oct. 2, 1899), a lower jaw from Samos in the Munich Palæontological Museum is described, and identified both with the *Leptodon* from Pikermi and with the Stuttgart fossil.

A description of the skull in the British Museum (Natural History), accompanied by figures, will be published shortly, when I shall more fully discuss its relations with the fossils described by the French, the American, and the German palæontologists.

The generic name *Leptodon* has to give place to *Pliohyrax*, the former being preoccupied by Sundevall's genus of Falconidæ (1835).

NOTICES OF MEMOIRS.

I.—NOTE ON THE SURFACE OF THE MOUNT SORREL GRANITE. By Professor W. W. WATTS, M.A., F.G.S.[1]

IT has long been known that, when first exposed in the quarries, the granite of Mount Sorrel exhibits a smoothed, grooved, and slightly terraced aspect. As the surface, when first discovered, was covered with boulder-clay, it has been concluded that it was produced by glaciation. The writer has long had doubts with regard to this interpretation, and recent excavations near Mount Sorrel have thrown a new light on the phenomenon. At Hawkley Wood and Nunckley Hill a similar but smaller surface has recently been exposed which is covered by undisturbed Keuper Marl, while a second surface, exposed at Nunckley Hill, has boulder-clay abutting on it. Thus the grooving, terracing, and smoothing, like so much of the scenery in Charnwood Forest, was originated in Triassic times, though locally it may have been somewhat modified by glaciation. The writer wishes to thank Mr. R. F. Martin for calling his attention to these newly exposed surfaces.

II.—NOTE ON BARIUM SULPHATE IN THE BUNTER SANDSTONE OF NORTH STAFFORDSHIRE. By C. B. WEDD, B.A., F.G.S.[1]

(Communicated by permission of the Director-General of the Geological Survey.)

SPECIAL attention has been directed by Professor F. Clowes to the deposition of barium sulphate as a cementing material of Triassic Sandstone near Nottingham, and he has mentioned numerous places, on the authority of Mr. J. Lomas, where the same mineral has been observed in Triassic rocks.[2]

It may be interesting to record another locality. In a cutting of the North Staffordshire Railway (Audley Branch), three-quarters of a mile south of Alsager Road (Talke) Station, a section of Bunter Sandstone in Merelake Hill shows the cross-like marks common in the Keuper Sandstone of Cheshire and Staffordshire, and due to barium sulphate crystals. A partial analysis, made by my friend Mr. R. Hornby, of the Red Bunter Sandstone of Merelake Hill, showed a considerable quantity of barium sulphate. Occasional veins filling joints consist of barytocelestite, which may also be seen in other sections of the Bunter of Merelake Hill.

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[1] Abstract of a paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Proc. Roy. Soc., vol. lxiv, p. 374. References to previous papers are given in this article.

III.—THE METEOROLOGICAL CONDITIONS OF NORTH-WESTERN EUROPE DURING THE PLIOCENE AND GLACIAL PERIODS.[1] By F. W. HARMER, F.G.S.

NO satisfactory explanation has yet been offered as to the conditions under which originated the great sheets of shelly sand known to geologists as the Upper Crag, the littoral deposits of the North Sea in Pliocene times, which contain everywhere (over an area in East Anglia more than sixty miles in length) the dead shells of mollusca in the most extraordinary profusion. No such accumulations are now taking place on the shores of Norfolk and Suffolk, although molluscan life is more or less abundant in the adjoining seas. On the coast of Holland, on the contrary, dead shells are exceedingly common.

The occurrence of such débris is local rather than general, and seems to be due, sometimes to currents, but more frequently to the action of stormy winds, which agitate the sea bottom to a greater or less depth. An examination of the daily weather charts issued by the Meteorological Office shows that movement of dead shells towards the shore at any place is for the most part in the direction of the gales which may be prevalent. At present the cyclonic disturbances, to which East Anglian storms are due, pass as a rule with their centres to the north-west of that district; and hence south-westerly and westerly gales are there common, and shelly débris is driven on to the shores of Holland, and not on to those of the east of England. It would seem, therefore, that during the Pliocene epoch strong winds from the east must have prevailed in the Crag area. At an early stage of the Red Crag period, mollusca now confined to the Arctic Circle had begun to establish themselves in the Crag basin, so that the glaciation of Scandinavia, attended with anticyclonic conditions over that country, had probably then commenced. At present, when Scandinavia is anticyclonic, storm centres may be diverted from their usual course towards the south, as was the case, for example, in October, 1898, causing south-easterly and easterly gales, with rough sea on the eastern coasts of England. It is suggested that such conditions may have frequently prevailed there during the Crag period.

The meteorological conditions of the Northern Hemisphere during the Glacial epoch must have been widely different from those of our own time. At present the accumulation of ice-sheets in the Arctic regions is local rather than general; Greenland, for example, being glaciated, while the north of Scandinavia enjoys a milder climate. The latter is due, partly to the Gulf Stream, but partly also to the prevalence of south-westerly winds, caused by the relative positions occupied by areas of high and low pressure. Nansen states that a constant area of high-pressure now exists over Greenland, and that the winds blow outwards from that country in all directions. Similar conditions probably obtained during the Glacial Period over the great ice-sheet of Northern Europe, producing the most far-reaching changes on the climate of different parts of the Northern Hemisphere; and this may, to some extent, explain the local character of the accumulation of great masses of snow and ice during that epoch.

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[1] Read in Section C (Geology), British Association, Dover Meeting, Sept. 1899.

REVIEWS.

I.—THE SURVEY MEMOIR ON THE SCOTTISH UPLANDS.[1]

(*Concluded from p.* 479.)

THE volume opens with a preface by the Director-General giving in outline the *raison d'être* of the work, the mode of its preparation, and the names of the Survey officers concerned in working out the geological facts and phenomena described. In Chapter I a very short description is given of the physical characteristics of the Upland region; and then in Chapter II, a "History of Previous Researches among the Silurian Rocks of the South of Scotland," the writers enter upon the subject-matter of their work in earnest. In this second chapter the whole history of research in the Uplands is passed in review, from the days when Hutton and Hall laid here the foundations of stratigraphical and tectonical geology, down to the present time. The work of all the chief stratigraphical investigators—Moore, Nicol, Harkness, Sedgwick, Murchison, and others—is first noticed in outline. There are abundant references to those palæontologists who have studied the fossils of these rocks—Salter, McCoy, Carruthers, Hopkinson, Davidson, Henderson, Etheridge, Nicholson, Hinde, etc. An account is given of the earlier *formational* mapping by the Survey officers, and its results summarized, explained, and discussed. Next the work of the *zonal* geologists is taken up, and treated in some detail. And, finally, we have a summary of the progress and results of the Survey revision as carried out in the years 1888 to 1898; from which it would appear that well before the close of 1888 the Survey officers had convinced themselves of the accuracy and availability of the zonal methods, and that since that time they have employed them continuously and successfully in developing the stratigraphy and tectonics of the whole of the Upland region.

It is hardly possible to praise the tone of this chapter too highly. It is evident that an attempt has been made to treat all contributions to the literature of the subject as historical documents, with perfect impartiality. The main conclusions of all observers, official and non-official, are given in brief, and discussed openly and frankly in the light of present geological knowledge and opinion.

In Chapter III we are presented with a summary of the whole geological story of the Uplands, from a stratigraphical point of view. Each of the great Upland formations—Arenig, Llandeilo, Caradoc, Llandovery, Tarannon, Wenlock-Ludlow, and Downtonian—is described under the headings of rocks, fossils, and conditions of deposition.

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[1] Memoirs of the Geological Survey of the United Kingdom: "The Silurian Rocks of Britain," vol. i, Scotland, 1899.

For convenience of description the tableland is divided into five geographical belts, viz.: (i) the Southern Belt, comprising the Wenlock-Ludlow area, which runs along the south-west flanks of the Uplands; (ii) the Central Belt or the Upland region proper, which, forming a continuous band some 25 miles in width, sweeps through the heart of the country from St. Abbs Head to the Mull of Galloway, and is floored mainly by Llandovery and Tarannon rocks; (iii) the Northern Belt, which ranges from Dunbar through the Leadhills region to the sea-coast north of Portpatrick, and is floored wholly by Ordovician (Lower Silurian) strata; (iv) the Girvan (and Ballantrae) area; and (v) the area of the inliers of Lanark and the Pentlands.

It is difficult to say which of the peculiar phenomena of the Upland succession, as now accepted after the researches and discoveries of Messrs. Peach, Horne, and M'Connochie, is the most interesting,—the extraordinary tenuity of some of its rock-formations in some districts when contrasted with their extraordinary thickness in others; the striking monotony of their lithology and fauna in one area, as contrasted with the equally striking variety in another; or, perhaps most remarkable of all, the certainty with which the sequence can be unravelled, in spite of the excessive wrinkling and puckerings which the rocks have undergone.

Three of the massive Lower Ordovician formations of Southern Britain—the Upper Arenig, Lower Llandeilo, and Upper Llandeilo, inclusive—are now known to be collectively represented in the Uplands by a thin sheet of Radiolarian chert, only some 70 feet in thickness, which shows through at the surface in numberless anticlinal forms over an area of some 2,000 square miles. Below this chert sheet lies a basement formation—the Ballantrae volcanic series—with a few Middle Arenig graptolites in its higher members; above it follow shales with Upper Llandeilo graptolites. But the chert sheet itself is as yet barren of all fossils except Radiolaria; so that the rich graptolite fauna of the Upper Arenig-Lower Llandeilo formations (Llanvirn), so remarkable in Southern Britain and Scandinavia for its characteristic tuning-fork graptolites (*Didymograptus Murchisoni*), is in the Uplands conspicuous by its absence.

Almost the same extraordinary condensation marks the succeeding Upland rock groups—the Glenkiln, Hartfell, and Birkhill black shales (Moffat Series)—which in the Moffat country answer to the Upper Llandeilo, Caradoc, and Llandovery formations of Siluria. They contain, however, the richest and most varied graptolite fauna known, and their species group themselves in well-marked, consecutive, palæontological zones.

But as we pass outwards from the typical Moffat region to the north-east, north, and north-west, grey shales, grits, and greywackes come in among the black shales, thickening and modifying each zone in turn, commencing from above; so that finally, when we have reached the distant Girvan region, all the thin-bedded black shale zones of Moffat have disappeared as such, and are now represented by thick rock sheets of very varied lithological types, rich in most of the classes of invertebrate life. But through all these changes, from end to end of the Uplands, we find at intervals among the arenaceous deposits layers with characteristic Moffat graptolites, which enable us to parallel with certainty all the expanding divisions of the Moffat succession, and trace them from point to point, and district to district, through all their variations in lithology, thickness, and palæontology.

The systematic place and geographical distribution of the zones of the Moffat Series, typical and expanded, being thus established, the remainder of the Upland formations fall naturally into line. The overlying wide-spreading sheet of greywackes and grits (Gala or Queensberry Series) is shown both by superposition and by characteristic graptolites to be the equivalent of the Tarannon. The succeeding formations of Riccarton and the Pentland Hills answer both by systematic position and by fossils to the Wenlock-Lower Ludlow formation; and finally, resting upon these Wenlock-Ludlow rocks in Lanarkshire and Midlothian, come the Scottish equivalents of the Passage Beds (Downtonian) of Siluria.

In Chapter IV Mr. Teall deals with the petrology of the igneous rocks associated with the stratified deposits of the Uplands. Few of the points worked out during the revision of the Upland geology has exceeded in interest the establishment of the facts, that the typical members of the disputed rock series of Ballantrae are true contemporaneous lavas and tuffs, and that all the unquestionably intrusive masses associated with them are, with the exception of a few Tertiary dykes, of pre-Bala age. The Ballantrae lavas belong to a great basement volcanic series of Arenig age, which, underlying the sheet of Radiolarian chert, has now been proved by the Survey to actually show through at the surface, in numberless eroded anticlines, over a collective area of some 1,500 square miles. The lavas are mainly diabases or diabase porphyrites, and are characterized by a remarkable 'pillow structure.' Mr. Teall points out with striking effect how both the structure and the composition of these pillow lavas resemble those of the volcanic rocks similarly associated with Radiolarian cherts in such widely separated localities as California, Cornwall, and Saxony, while their accompanying agglomerates and tuffs call to mind those of the disputed districts of Rhobell Fawr and Predazzo; and further, in almost all these widely separated localities, British and foreign, these peculiar volcanic rocks, both effusive and pyroclastic, are pierced by plutonic or intrusive rocks which agree in certain peculiarities of composition, texture, and structure, and in the difficulties which they present to the geologist who endeavours to determine their relative order of intrusion. It is possible that, as in the parallel case of the igneous rocks with pillow structures, and associated pyroclastic rocks, etc., of the Ordovician of Shropshire and Radnor, we are dealing with a distinctly submarine igneous series, probably extruded at great depths in the sea.

All the foregoing chapters may be regarded as introductory to the main purpose of the volume, namely, the detailed description of the geology of the several districts that make up the Upland region as a whole, and the systematic demonstration, stage by stage, of the true succession of its recognizable formations, and their regional variations, characteristic organic remains, and tectonic development. This occupies the main body of the work from the beginning of Chapter V to the end of Chapter XXIV.

These chapters are illustrated by more than a hundred sketch-plans and sections, scattered through the letter-press, prepared by Mr. Peach from the field observations of himself and Mr. Horne. These figures exemplify the large amount of detailed work demanded in the zonal mapping of a country so complicated as that of the Southern Uplands, and numerous as they are, probably not one of them could have been dispensed with. As a finished model for workers in the zonal methods of geology, we doubt whether anything could excel the sketch-plans of Rae Grain (Craigmichan Scaurs) (p. 102), of Morroch Bay (p. 402), and of the Ballantrae Coast line (p. 433); or the sections of Rae Grain (p. 104) and Bennane Coast (p. 434); or, perhaps most remarkable of all, the sketch-plan and section of Lorg Burn (p. 359). These sketch-plans and sections, insignificant as might appear to the older geologists to be the extent of ground illustrated by each—sometimes only a few thousands of square yards in extent—are not only of vital consequence in the development of detailed local successions, but they present in miniature, again and again, many of the tectonic phenomena characteristic of the region as a whole.

Where so much has been given in this department, it is perhaps ungracious to expect more, but when we look at the sketch-map of the Ettrickbridge-end exposure on p. 121, good as it is, we must confess to a feeling of disappointment. It is evident that this miniature plan affords but a very inadequate idea of the care, time, and labour which must have been expended by the Survey officers on this locality. There is no exposure in the country to the east of the Moffat district so vital for purposes of correlation as the one at this spot; and I know, from personal experience, there is not one which is so difficult of accurate interpretation and representation in detail. The Survey work here has been done so thoroughly that it is well worthy of a double-page map and corresponding sections.

These chapters upon the detailed geology commence with a description of the typical area of the Moffat district, as affording the natural key to the complicated stratigraphy of the Uplands as a whole. The entire sequence of the zones of the Moffat Series is redemonstrated and the published nomenclature accepted. But with the confidence generated by the successful testing and retesting of the zonal methods, the officers of the Survey not only simplify the detailed sections across the typical exposures, but carry more or less generalized sections boldly across country from exposure to exposure. They illustrate the type localities of Dobb's Linn and Craigmichan Scaurs by several new sections, the former by an improved sketch-plan, and they describe and illustrate *seriatim* all the more important exposures throughout the whole of the Moffat district.

It is evident that the authors take it for granted that the reader is already more or less familiar with my paper on the Moffat Series, and many of the new lines of section may be regarded as supplementary to, or corrective of, those given in that paper. But the new sections are delightfully clear, the descriptions terse and condensed, and our knowledge of the geology of the district is advanced by some important discoveries.

One of the new discoveries made here by the Survey officers is of especial importance. They have ascertained that typical Glenkiln graptolites range up into the two to three feet of black and grey shales overlying the band of Glenkiln Radiolarian cherts above the *Cænograptus* zone. They have therefore properly classed these shales with the Upper Glenkiln, instead of the Lower Hartfell (*C. Wilsoni* zone), to which they were assigned by myself. They have recognized this special subzone with its characteristic fossils at Dobb's Linn, Hartfell, etc. This discovery enables us to correlate with certainty a group of strata characterized by similar fossils which proved most tantalizing to myself and others in the geology of the Leadhills district and elsewhere.

The sequence of the Moffat graptolite zones having thus been established in the typical area upon an impregnable basis, the officers of the Survey next show how the same palæontological succession obtains in all the exposures of black shales occurring in the Central Belt of the Uplands from St. Abbs Head to the Mull of Galloway. They unravel by means of these graptolite zones the entangled and complicated rock-formations which occur in the many exposures of black shale in this region, and place before the reader in most instances the proofs of their conclusions in the form of sketch-plans, sections, and lists of fossils. They demonstrate, by means of the evidences they bring forward, the identity of the so-called Axial series with the Queensberry group. They show that in some few places where the anticlinal forms have been mostly deeply eroded, as at Trowdale Glen, etc., the entire Glenkiln Series has been cut through, exposing a well-marked Radiolarian chert zone below it, and that in two instances at least even this chert zone has been cut through, laying bare a basement series of volcanic rocks which they parallel with the Arenig volcanic series of Ballantrae.

While the Moffat Series remains practically unmodified when followed from Dobb's Linn along the strike of the beds, every zone retaining more or less its typical characters and thickness, it changes rapidly when followed in the direction of the dip—the sheet of overlying greywackes descending deeper and deeper into the series as we pass to the north, replacing each black shale bed in turn, until by the time we have reached the northern limit of the Central Belt, the arenaceous facies has descended to the middle zone of the collective series—the whole of the Birkhill shales and Upper Hartfell being there represented by a grand thickness of greywackes, grits, conglomerates, and shales.

Everywhere, as in the Moffat country, the massive arenaceous group of the Gala-Tarannon succeeds at once to the Moffat Series throughout the whole of the Central Belt. But it is evident that the assumption of the arenaceous facies by successive zones of the Birkhill division as we pass from the Moffat country northward renders it difficult, if not impossible, to fix in every instance the horizon where the Birkhill strata end, and the Gala beds begin. This monotony of lithological facies is especially tantalizing along the northern edge of the Central Belt, where the arenaceous facies has descended far into the heart of the Hartfell itself. The northern boundary of the Central Belt is presumably defined as the outcrop of the line which divides the local Hartfell from the local Birkhill—i.e., it is the line of division between the Ordovician and Silurian of the Uplands. But the lithological transition between the strata of the two systems is here almost as gradual as that between the Cambrian and Ordovician of other countries, and the line laid down upon the map by the officers of the Survey is therefore admittedly generalized and provisional.

A few observations may here be made with reference to the names of the graptolite species cited in the abundant fossil lists scattered through the work. These lists may each be regarded from two aspects, the one stratigraphical and the other palæontological. Regarded from the stratigraphical aspect the lists subserve well the purposes for which they have been drawn up, namely, those of correlating the beds which contain them with the type zones of Moffat and Girvan. The general association of forms is usually sufficient for this purpose, and the exact identification *in situ* of every species as at present defined by the graptolithologist is from this point of view a matter of no great moment. But regarded from the palæontological aspect the matter is very different. The names of many of the forms given in the lists must be read as provisional and suggestive only, namely, as those of species which are called to mind by the form detected at the locality: for example, the forms united under *Monograptus Hisingeri* may in reality belong to several distinct species; the same is the case with *M. tenuis*, *M. priodon*, *M. lobiferus*, *M. turriculatus*, *Dimorphograptus Swanstoni*, *Dicranograptus ramosus*, and others.

Here perhaps we may also call attention to a practice of palæontologists, admirable enough in its way, but which, when carried out to the extent displayed in the present work, borders very closely on the ridiculous. We refer to the habit of appending the name of the founder of each species in every instance where that species is cited. For example, such titles as *Diplograptus foliaceus* (Murch.), *Dicranograptus ramosus* (Hall), *Monograptus gregarius* (Lapw.), occur hundreds of times within the cover of this volume. Now there can be no question that it is advisable for the sake of scientific accuracy that the reader should be told what special form the writer regards as the type of the species identified; but having appended the name of the founder to that of the species once in his general table of species and once where it is first mentioned in the body of the work, the writer has done all that can be reasonably expected of him. Any further reference is uncalled for. Such vain repetition can only add unnecessarily to the amount of the printer's bill, and increase, what is already amply sufficient for scientific purposes, the vanity of the species-maker himself.

In their work among the rocks of the Central Belt, already noticed, the Survey officers were mapping ground where the typical sections had already been worked out and the general sequence ascertained. The aim and end of their researches was that of interpreting the complicated structure of the whole belt in terms of the part. But in their work in the Northern Belt, which ranges from Dunbar, through the Leadhills to Loch Ryan, they were dealing with a country of which little was known and less published. It is true that it was already acknowledged that in this belt the greywacke type of sedimentation had descended well into the heart of the Caradoc (Hartfell) formation, so that all that remained of the black-shale type of the Moffat Series was a degenerate Glenkiln-Hartfell group of the characteristic Moffat facies and tenuity, ranging upwards no higher than the base of the Upper Hartfell. It was also known that this Moffat-like band, although rich in graptolites, is exceedingly difficult of unravelment, not only owing to the incoming of arenaceous and ashy members among the black shales, but also because of the unusually excessive wrinkling and puckering, dislocation and alteration, which the rocks of the country have undergone.

It is perhaps in this Northern Belt that the discoveries of the Survey officers have been most brilliant, and the value of the zonal methods most triumphantly demonstrated by them, but the great difficulty of their task will be appreciated on a study of the numerous sketch-maps and sections given in the chapters which illustrate their researches into the remarkably complicated structure of this region. They show that the 30 feet or so of Barren mudstones of Upper Hartfell age in the Moffat district have here become transformed into a massive series of grey and blue micaceous flags and shales (Lowther or Heriot Shales), with conglomerates and limestone bands. The Survey officers have proved for the first time that to this horizon belong the famous limestone beds of *Wrae Hill*, which they have ascertained are associated with a remarkable contemporaneous series of volcanic rocks, felsitic lavas and tuffs, apparently representatives of the rhyolitic lavas and ashes of Snowdon.

The Glenkiln - Lower Hartfell Series presents marked and often rapid lithological variations. The Lower Hartfell graptolitic black shales with flinty bands pass laterally into greywackes and calcareous conglomerates, occasionally rich in fossils (Duntercleugh Beds), and often with local unconformities presenting many peculiar features. Similarly, the Glenkiln graptolitic shales and cherty beds pass laterally into massive grits, greywackes, and shales some 1,200 feet in vertical extent.

From underneath the Glenkiln Beds rises again and again the sheet of Radiolarian chert, which varies but little in thickness, 60 to 70 feet from end to end of the country. From beneath this chert sheet emerges in its turn a basement volcanic series of pillow lavas, volcanic agglomerates and tuffs, with some Arenig graptolites and other fossils in their highest zone, and answering to the volcanic series of Ballantrae.

This Northern maze thus satisfactorily unravelled, the Survey officers enter next upon the description of the Girvan district, which is supposed to commence at the great Glen App fault. They give a most interesting account of the coast sections between Glen App and Ballantrae, where at the localities of Portandea, Currarie, and Downan, they have discovered the complete sequence from the Arenig (Ballantrae) volcanic rocks, through Radiolarian chert bands into mudstones and greywackes (Tappin's group), with a typical Glenkiln fauna.

The descriptions of these important localities are illustrated by several beautiful photographs by Mr. R. Lunn, showing the 'pillow'-form masses of lava, with their remarkable vesicular structures, and with beds of limestone and Radiolarian chert filling spaces between the pillow-like forms.

The authors next plunge into the Ballantrae volcanic and plutonic complex north of Stinchar Valley. The key section of Bennane Head is first described; the relationship of its Arenig graptolitic (or *Tetragraptus*) bands to the underlying volcanic series and the overlying Radiolarian chert bands is clearly demonstrated, and is illustrated by capital sketch-maps, sections, and photographs. From this key locality the beds of the complex are traced stage by stage along the whole Ballantrae coastline to Kennedy's Pass. The authors show how accurate were Professor Bonney's original conclusions as to the volcanic nature of many of these strata, and the similarity of the associated intrusives with those of the Lizard district. They establish in a general way the sequence of the entire succession of the Ballantrae rocks both along the shore and on land, as at Cragneil and Craighead, and they cite several new localities for Arenig graptolites in the series older than the zone discovered by myself at Bennane Head. Finally, they prove conclusively that the whole of this Ballantrae complex (some of whose plutonic members were erroneously regarded by myself and others to be of post-Girvan age), volcanic and plutonic rocks alike, is of more ancient date than the basal beds of the Barr series, which actually rest upon the volcanic platform, and contain abundant rounded pebbles or fragments of nearly all its known rock-varieties.

In Chapters XXI and XXII we have a summary of the stratigraphy and palæontology of the overlying Girvan formations. The classification and sequence of the various members of the succession, as worked out in my Girvan paper, are again shown to be the natural ones, and the various graptolite zones which enable us to parallel the beds with the Moffat and Upland succession generally are carefully checked and discussed. The Balclatchie beds are, however, now transferred to the base of the Ardmillan Series, and the Blair and

Straiton Beds are definitely assigned to the Wenlock. Long lists of fossils are given both of those collected by the Survey and by others. It is pleasant to note how freely the Survey officers have availed themselves of the fossil lists prepared for them by Mrs. Robert Gray from her magnificent Girvan collection, and how frankly and generously they refer to the value of her work. It is not too much to say that this Gray Collection has proved most important in aiding in the working out of the complexities of the Girvan-Ballantrae district, and in correlating its component formations, not only in the hands of the Survey officers, but in those of their predecessors. How enthusiastically, and yet at the same time how carefully, that collection was made, I can speak from personal knowledge. I look back to many a delightful day spent in the field in the company of Mr. and Mrs. Gray and their family, and I noted the extreme care with which every fresh specimen collected was at once labelled and packed away, so that there should be no future dispute as to the exact spot and horizon where it was obtained.

Chapter XXIII is devoted to a description of the Southern Belt, where the Wenlock-Ludlow (Riccarton) sediments follow conformably upon the Hawick Beds (Tarannon), and range along the south-east flanks of the Borderland. It is shown that the lowest of the recognizable zones here met with is that of *Cyrtograptus Murchisoni*, which the Survey collectors have now traced at or near the base of the series, almost from Jedburgh to the shores of Wigton Bay.

Chapters XXIV and XXV, which deal with the Lanarkshire inliers and those of the Pentland Hills, are fertile in new stratigraphical and palæontological discoveries and in improvements in classification. A novel assemblage of fishes (comprising five genera, four of which and seven species are new), detected in these beds by Mr. M'Connochie during the progress of the revision, is remarkable in many ways. According to Dr. Traquair, "zoologically the interest of these fishes is extreme, and this fauna has opened out to us a new vista in the field of Palæozoic ichthyology." With these fishes are associated representatives of all the genera of Eurypteridæ found in the Ludlow rocks. All these fossils occur in a series of red and yellow sandstones, red and green mudstones and conglomerates, some 2000 - 3000 feet in thickness, which graduate upwards conformably from the grey Wenlock-Ludlow Series of Lanarkshire and Pentland Hills, but have hitherto been classed as the basal member of the Old Red Sandstone. But the peculiar features of these fossils, however, as now ascertained, ally this rock group rather with the Passage Beds strata (Downtonian), which in Shropshire and elsewhere intervene between the Aymestry Limestone and the base of the Herefordshire Old Red Sandstone. This circumstance, together with the fact that this rock group underlies the more typical members of the Scottish Old Red Sandstone unconformably, has prompted the officers of the Survey to regard the whole of it as of Downtonian age, and as forming the terminal member of the Scottish Silurian. On this view first advocated by Messrs. Brown and Henderson several years ago, many controversial difficulties disappear, the views of local amateurs and the views of the Survey are harmonized, and the Scottish Silurian brought into closer parallelism with the Silurian of Southern Britain and elsewhere.

In Chapter XXVI Mr. Teall furnishes us with a masterly summary of his petrological researches into the characters and constitution of the Galloway granites and their associated rocks, founded mainly upon materials collected during this revision of the Uplands. He shows that the three granitic masses of Criffel, Loch Dee, and the Cairnsmore of Fleet present such resemblances and differences as are best explained by granting that they belong to the same petrological province, and in all likelihood were derived from the same magma basin. In average composition the Criffel mass is the most basic—being a tonalite rather than a true granite; the Cairnsmore mass the most acid—a biotite granite; and the Loch Dee mass intermediate in character—a hornblende granite. But in each mass we find rocks which are more acid and more basic than the average, extreme types being represented by hyperites and muscovite-biotite granites; but between the most extreme types we have a continuous series of intermediate varieties.

The curious resemblances which obtain between these Galloway rocks and similar petrological types of other areas in Britain and abroad, in widely separated districts, and in rocks of different geological age, are pointed out, and the conclusions are drawn that plutonic rocks, like minerals, are subject to paragenesis; and that in Galloway, as elsewhere, the phenomena are in accord rather with the differentiation hypothesis than with that of assimilation.

The petrological reader will follow with keen interest the descriptions of the minuter characters of the rock masses and rock varieties—the veins, the dykes, the foliated rocks, the aureoles of metamorphism and their characteristic phenomena—as given by Mr. Teall in this and the following chapter, and discussed in brief in their relation to each other and to the unsettled problems of petrological science in general.

When we recollect that, in addition to these special chapters, the volume is enriched by numerous petrological descriptions, scattered like the sketch-plans and sections through its pages, we appreciate how important a rôle the science of petrology has now begun to play in the development of the geology of every complicated region. This petrological work is illustrated by several excellent microphotographs, but it is to be lamented that it is accompanied by so few chemical analyses.

The final chapter in the volume deals with the Economic products of the Upland rocks—the building-stones, the granites, the ornamental stones, the workable ores, etc. We consider this chapter, more especially because of its brevity, as the least satisfactory in the book. The economic geology, as such, is as much the province of the geologist, and demands as respectful a treatment, as the detailed stratigraphy of a country. Not only are the facts connected with the former especially well known to the Surveyman, but they appeal peculiarly to the business mind of his employer, the Britisher in general. But indeed, as it has been well said, not one of us, if we are scientists at heart, can afford to ignore any branch of our science, "even though it be conspicuously — and even glaringly—useful."

At the end of the work we have an Appendix, containing several carefully prepared tables; a general list of the Upland graptolites collected by the Survey, showing the formations they characterize; a general list of all the Upland fossils of other classes in the Survey collections; a list of fossil species prepared by Mrs. Gray from her fine Girvan collection; comparative tables of fossils from the Stinchar Series, the Balclatchie Beds and their equivalents, etc.; from the Wenlock-Ludlow formations; and finally, a complete bibliography. We have already referred to the many illustrations collected together at the end of the book, but the absence of plates of the characteristic forms of the group of the Radiolaria, which has proved itself of such high import in the formation of perhaps the most remarkable of the Upland rock sheets, is much to be regretted.

We have already pointed out how the field observations in the revision of the Uplands were conjointly the work of Messrs. Peach and Horne, assisted by Mr. M'Connochie as fossil collector. The graptolites were identified mainly by Mr. Peach, the various other fossils were classified and arranged by him, and he also prepared all the illustrative diagrams, sketch-plans, and sections. The exacting task of arranging the materials and of writing almost the whole of this most interesting volume has fallen to the share of Mr. Horne, and the Director General has edited the whole.

The book is alive throughout with interest and enthusiasm, and it is well abreast, if indeed it is not well in advance, of anything yet done in this special department abroad. It is evident that the authors have spared themselves neither time nor trouble to arrive at correct results and conclusions. It affords another proof, if such were needed, that zonal work is probably destined to effect in the history of geological research a revolution as great and an advance as rapid as those brought about by the use of the microscope in the history of biology. This volume does not mark the close of geological investigation in the Uplands. It marks rather its true beginning.

CHAS. LAPWORTH.

II.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY FOR 1898. 8vo; pp. 216. (London: Eyre & Spottiswoode, 1898. Price 1s.)

LAST year, in the GEOLOGICAL MAGAZINE for July and August (pp. 306 and 358), we drew attention to the first issue of this "Summary of Progress," which was prefaced by a full history of the origin of the Geological Survey and Museum of Practical Geology.

The present "Summary" gives a very detailed account of the observations made in the field and in the palæontological and petrographical departments during the past year. The record is one which indeed reflects credit on the small band of enthusiastic workers which compose the Survey. Their reports have been pieced together by the Director General, who has himself contributed notes on the Dalradian schists and Old Red volcanic rocks near Oban, on the volcanic rocks in the Carboniferous Series of Somerset, and on the older rocks of Skye and Scalpa.

It is hardly possible to do more than glance generally at the contents of this detailed report. The subject-matter is arranged in stratigraphical order, beginning with the Pre-Cambrian rocks of Ross-shire and continuing to the Peat-bogs of Ireland. Something of interest will be found for all students and workers, in the occurrence of minerals and fossils, in the discussions on schists and rock-structures, in the accounts of volcanic and plutonic rocks, of contact metamorphism, faults and foldings, in the descriptions of new railway-cuttings, well-borings, and in the analyses of dolomites and iron-ore.

The accounts of the Pre-Cambrian rocks of Ross-shire contain much that is interesting, while on some points further information is desirable. Mr. Peach divides the rocks into two main groups—(1) the Lewisian gneisses and (2) the Moine type of gneisses and muscovite-biotite-schists. The Lewisian gneiss is supposed to be the older, and is stated (p. 7) to have been "thrust forward among the Moine schists," but there does not seem to be any clear evidence of this, for a little further on he says "there seems to be a definite order in at least the local succession," and the "Moine schists always lie next to the older gneisses, while the centres of the synclines of these schists are occupied by the muscovite-biotite gneiss." This does not give the impression of a "thrust-plane" junction, and, indeed, it is practically stated only a few lines further on that the junction is an unconformity. If this is so, one would expect a pebbly base to the Moines, but no mention of such a base occurs. Neither is there any information as to the age of the crystallization of the two groups of rocks, whether they are of the same age or not. An interesting series of foliated granites is described on p. 9.

Mr. Horne, in the Fannich area, gives an account of several rock-groups that he has been able to map out, which are a continuation of those already mapped by Mr. Gunn. Five of these are mentioned in "what appears to be descending order." The remarkable part of this sequence is that No. 1, or the highest, is stated to "resemble certain types of Lewisian gneiss." The lowest, No. 5, is obviously the same as the lower member of the Moine schist of Mr. Peach. The difficulty with regard to No. 1 is recognized by Mr. Horne, who suggests two explanations of it, the first of which indicates a structure similar to that of the Archæan gneiss of Loch Maree. We may also note (p. 15) that No. 5, the most persistent type of the Moine schists, was probably crystallized "prior to the Post-Cambrian movements."

Mr. T. I. Pocock describes somewhat similar groups, but on p. 17 the following statement is made:—"The basic portions of the granitoid gneiss usually appear as hornblende-schist dykes, traceable for short distances, and folded with the main mass of the rock. East and west of the main outcrop of flaky gneiss, but folded with it, are masses of quartzose gneiss belonging probably to the Moine-schist series, but placed in this group on account of the presence of hornblende-schist dykes. In many parts the rock is indistinguishable from the typical quartzose Moine-schist, whilst in others the occurrence of thin felspathic folia and 'eyes' associates it with the Acid gneiss." Apparently the grouping of these rocks is made to depend on the presence or absence of hornblende-schist dykes. We would like to know more of these hornblende-schist dykes. Are they of the same age as the Scourie dykes, or what is their age?

Under the term "Dalradian or younger schists of the Highlands" are included the rocks of the Central Highlands. The heading suggests that these rocks are newer than those last described. We should like to know the evidence of these being "newer gneisses." Has any evidence on this point been published? And if so, where?

Mr. Barrow draws attention to the identity in structure and appearance of the rocks of the Braemar area with the Moines described above by Mr. Peach and Mr. Horne, and he traces their connection with the quartzite and limestone series of the Central Highlands. Mr. Cunningham Craig also describes a series of rocks closely resembling the quartzose phase of the Moine schists or gneisses, and he too connects these with the quartzite and limestone series.

In the notes on the "younger granites of the Grampian Hills," the large masses of the Central Grampians and the smaller intrusions of much the same age, are described in detail by Messrs. Barrow, Cunningham Craig, and Hinxman. Messrs. Hinxman and Craig give evidence showing the thermo-metamorphism produced by these granites.

Leaving the Dalradian schists we come to accounts of fossils from the Cambrian rocks of Skye, and to records of fossiliferous Silurian rocks in Ireland. Another new genus and species of fossil fish from the Upper Silurian rocks of Lesmahagow, *Ateleaspis tessellata*, is named by Dr. Traquair. Several good specimens of a new species of *Eurypterus* of the type of *E. scorpoides*, Woodw., were collected from the Downtonian rocks of Ayrshire and Lanarkshire. In Caithness, Ross-shire, and the Lorne much new information was obtained regarding the Old Red Sandstone, while the granites of Ben Cruachan and Glen Etive and the effects of contact metamorphism were attentively studied by Mr. Kynaston, aided by Mr. Teall. To the latter we owe the discovery of corundum among the cordierite-bearing rocks of the contact zone round the Ben Cruachan granite.

The resurvey of the South Wales Coalfield and bordering rocks has been vigorously pursued by Mr. Strahan, Mr. Tiddeman, and Mr. Cantrill, and much new information has been gathered with reference to the structure of the Vale of Neath and of the superficial coverings of Glacial Drift. In Devonshire and Cornwall, Mr. Ussher, Mr. J. B. Hill, and Mr. S. B. Wilkinson have been busily at work, while in North Staffordshire Mr. Walcot Gibson reports a considerable extension of the Coal-measures under Little Madeley and Craddocks Moss.[1] He notes also his discovery of a new bed of iron-ore in the Fenton Park Clay-pits, and an analysis of the rock is contributed by Dr. Pollard.

Various members of the staff furnish notes on Permian, Trias, Jurassic, and Cretaceous rocks, and they give many particulars of the Glacial drifts. Mr. Harker's observations on the Tertiary igneous rocks of Skye deal largely with the very numerous basaltic sills which have been intruded into the basaltic lavas. These sills are for the most part younger than any of the great plutonic intrusions of basalt or granophyre.

In illustration of the work done on the Glacial Drifts we may refer to the observations made by Mr. G. W. Lamplugh in the neighbourhood of Uttoxeter in North Staffordshire. He remarks that the prevalent Drift of the higher ground is a red sandy loam, or, more rarely, clay, containing numerous rounded quartzite and other pebbles derived from the Bunter (which frequently show the characteristic pittings), together with an occasional partially rounded fragment of hard sandstone probably derived from the Carboniferous rocks. The absence from a great part of the district of stones larger than one foot in diameter, and of any showing clear proof of glacial striation, together with the sandy character and local derivation of the material, seem to render the term 'boulder-clay' somewhat inapplicable to this deposit. Evidence was obtained, however, that in spite of its abnormal composition and general resemblance to 'rain-wash,' the material is the local equivalent of the true Boulder-clay of contiguous tracts, and has had a similar derivation from the moving mass of land-ice by which the whole country has been covered. The clearest proof of this was furnished by the presence of well-glaciated surfaces of Lower Keuper Sandstone at an elevation of 700 feet above O.D. (almost the highest ground in the neighbourhood), which were uncovered towards the end of last year in the large quarries at Hollington. These surfaces were directly overlain by the usual pebbly loam of the district, of rather unusual thickness (from 10 to 25 feet), and the direction of the striæ—W. 20° N. to E. 20° S.—shows that the movement of the ice has not been determined by the shape of the ground in the vicinity nor by the presence of the elevated Carboniferous Limestone tract of the Weaver Hills a few miles to the northward, but has been consequent upon the pressure of the great ice-sheet which was piled up over the lower ground to the westward and north-westward. As this is the only locality in the district where there is any rock sufficiently coherent to exhibit such traces of glaciation, it is fortunate that the quarry-sections should afford such opportune exposures.

Further evidence that the pebbly loam must be regarded as a local variety of the Boulder-clay of the great ice-sheet is afforded by the fact that on the rising ground south of Uttoxeter, opposite to the great bend in the Dove Valley, where the river swerves from a southerly to an easterly course, the pebbly loam is suddenly replaced by a true till in which large subangular striated boulders of Carboniferous Limestone, toadstone, and other rocks are abundant. This material evidently indicates the path taken by the stream of ice which has descended the valley of the Dove; and Mr. Lamplugh urges that its local development in relation to the more prevalent type of pebbly drift tells strongly in favour of the land-ice as opposed to the marine theory of the origin of these drifts.

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[1] *See paper read by* Mr. Gibson in Section C., Brit. Assoc. meeting at Dover.

Lists of memoirs and maps published and in hand are given at the end of this report, and it is accompanied by small index maps showing the state of progress of the surveys in different parts of the United Kingdom.

III.—The History of the European Fauna. By R. F. Scharff, B.Sc., Ph.D., F.Z.S. 8vo; pp. i–viii, 364, with 21 illustrations. (London: Walter Scott, 1899. Price 6s.)

THE present volume is the outcome of a memoir read by the author before the Royal Irish Academy, and originally published in their Proceedings for 1897. Of this communication we gave a lengthened notice in the Geological Magazine, 1897, Dec. IV, Vol. IV, pp. 420, 468.

Dr. Scharff is a naturalist in the true sense of the word, and gathers his illustrations of geographical distribution from plants and insects, crustacea and mollusca, as well as from birds and mammals. Nor are the facts and observations furnished by the geologist bearing upon the interesting problems of which he treats neglected by the author. In his Preface he says: "Our knowledge of the present and past fauna of Europe is as yet insufficient to indicate with precision the original homes of its component elements, but I hope that the lines of research laid down here, and the method of treatment adopted, will aid zoologists and geologists in collecting materials for a more comprehensive study of the history of our animals. I trust also that a fresh impulse will be given by the publication of this book to the study of the geographical distribution of species. Collectors of beetles, butterflies, shells, and fossils may derive some useful hints by its perusal, and thus direct their studies so as to add, by accuracy in observation, to our knowledge of the former geographical revolutions which have moulded our islands and continents. To geographers, a survey of some of the more important changes in the distribution of land and water in past times, based upon the composition of our fauna, will be interesting. The subject, however, is a complex one. I have ventured to indicate a suitable method of treatment, and as such this attempt to elucidate the history of the European fauna should be received." (p. v.)

"Every student of natural history," writes Dr. Scharff (p. 1), "whether he be interested in birds, butterflies, or shells, contributes his share of facts which help to show how the fauna of his country has originated. The capture of a swallow-tail or of a marbled white butterfly in England at once furnishes material for reflection as to the reason of its absence from Scotland and Ireland. Why should the nightingale allow its beautiful song to be heard in England, and never stray across the Channel to the sister isle or cross the borders of North Britain? Lovers of bird-life and sportsmen, who have observed the habits of the ptarmigan in the wild mountain recesses of Scotland, are aware that nowhere else in the British Islands do we meet with this interesting member of the grouse family, and many no doubt have allowed their minds to dwell upon the causes of its singularly local distribution.

"All these animals have a wide range in other parts of the world. In past times, before man began to make observations on the geographical distribution of birds and butterflies, or even before the appearance of man in Northern Europe, they may have lived all over the British Islands. For some reason or other they are perhaps dying out or withdrawing towards their original home, which may either be northward or to the east or south. If we had some clue as to their former history from fossil evidence—or, in other words, if their remains had been preserved to us in geological deposits—we should have less difficulty in deciding this problem. But butterflies are scarcely ever preserved in a fossil state, and birds very rarely. We know little or nothing, therefore, of their past history from direct evidence, and are obliged to trust to indirect methods of research, which will be indicated later on.

"Mammals and snails tell their story more plainly. The bones of the former and the shells of snails are easily preserved, and thus furnish us with the necessary data as to their past history, for we find them abundantly in most of the recent geological deposits. Among the mammals of the British Islands there are some instances of distribution which much resemble those I have quoted. Thus the Arctic Hare (*Lepus variabilis*) is in the British Islands confined to Ireland and to the mountains of Scotland; and if it were not for the fact that its bones have been discovered in a cave in the south-west of England, we should perhaps never have known that, formerly, it must have inhabited that country as well. Of other mammals we possess fossil and also historical evidence of their having once lived in these Islands, such as the wolf and the wild boar, both of which were abundant in Great Britain and Ireland. The latter is a distinctly southern species. We assume this because its remains have never been found in high northern latitudes; nor does it now occur in Northern Europe or Northern Asia, whilst all its nearest relatives live in sub-tropical or tropical climates. The Arctic Hare, on the contrary, has probably come to us from the north. Its remains are unknown even in Southern Europe, and the more we approach the Arctic regions the more abundant it becomes. Thus we have here two instances of British mammals, one of which, the wild boar, has died out, as it were, in a southerly direction; whilst the other, the Arctic Hare, is apparently retreating towards the north.

"There are also some British mammals of which we have no fossil history, at least of which no remains have as yet been found in these Islands. Such a one is the harvest-mouse (*Mus minutus*). It has a somewhat restricted range in England, and only just crosses the Scottish border in the east. From the rest of Scotland and from the whole of Ireland it is absent. To judge from this distribution, in connection with the fact of its being unknown as a British fossil species, it is probably a late immigrant to England, and has not had time to spread, through Scotland at any rate. But it is also absent from Scandinavia, from the Spanish Peninsula, from almost the whole of Italy and the Alps, as also from the Mediterranean islands, whilst the little mouse occurs abundantly right across Siberia. We shall learn more about centres of dispersion later on; meanwhile I should mention that such a distribution indicates that the harvest-mouse has most likely originated in the east, and has spread from there westward in recent geological times.

"Conchologists have long ago been acquainted with the fact that many molluscs, for example the so-called 'Stone-cutter' Snail (*Helix lapicida*) and the 'Cheese Snail' (*Helix obvoluta*), have a very restricted range in the British Islands. Both are entirely absent from Scotland and Ireland, the Cheese Snail being confined to South-Eastern England. The Stone-cutter has rather a wider range, is even known from a Welsh locality, and is met with as far north as Yorkshire. Their distribution would indicate, therefore, that while both are recent immigrants the Cheese Snail is probably the last comer. This supposition is in so far supported by fossil evidence, as the latter is unknown in a fossil state, whilst the Stone-cutter has been described by Messrs. Kennard & Woodward as occurring in the cave deposit known as Ightham-fissure, and also from several English Pleistocene and Holocene deposits. The Stone-cutter can scarcely be looked upon as a very recent immigrant in the light of this evidence, though we have no proof of its having ever had a much wider range in the British Islands than it has to-day.

"Among the lichens, which so abundantly cover the rocks and trees in South-Western Ireland, and which impart such a characteristic feature to the scenery, we find a beautifully spotted slug (*Geomaculus maculosus*). It is a stranger to the rest of the British Islands, and, indeed, occurs nowhere else in Northern Europe. We have to travel as far as Northern Portugal before we again meet with it; it is there also that its nearest relations live.

"Many more similar examples might be quoted, but enough, I think, has been said to show that the British fauna is made up of several elements whose original homes may be widely apart and in different directions. We have fossil evidence that some of the Northern species, and also a few of the southern ones, have become extinct within comparatively recent times, others are apparently on the verge of extinction, whilst many not only maintain their position in the constant struggle for existence, but are even extending their range." (p. 5.)

We are glad that Dr. Scharff has given us his views on the history of the European fauna in the form of a little book, as it was not so easy for the student to obtain access to the original paper in the Royal Irish Academy's Proceedings. The illustrations add greatly to the interest of the volume, but they might well have been more numerous. We are sure it is a book which will have many readers and some few critics. We have already made some criticisms on the original paper,[1] and will now only commend it to our readers in its present form as a most attractive little volume on a most fascinating subject by a very able and clever Naturalist.

CORRESPONDENCE.

THE LIMESTONE KNOLLS OF THE CRAVEN DISTRICT.

SIR,—In a recent suggestive paper on the Limestone Knolls of the Craven District (Q. J. G. S., vol. lv, 1899, pp. 327–358), Mr. Marr's criticisms of my views on the Keisley Limestone appear to demand some reply, as unfortunately I was not present when his paper was read. I do not intend to examine the plausibility of Mr. Marr's views of the origin of the Craven knolls, with which I have only a slight acquaintance in the field, though, as I have paid some attention to their fossils, I may remark in passing that he does not bring forward the least palæontological evidence in support of his conclusions. It is the neglect or lack of appreciation of the palæontological evidence furnished by the Keisley Limestone by which he escapes the difficulties in which he would otherwise be there involved. For it is not here a case, as Mr. Marr appears to think (op. cit., p. 356), of the relative abundance of fossils, but of an assemblage of fossils with a facies entirely distinct from that of the neighbouring strata. When Mr. Marr can prove that the fauna of the thin white limestone which apparently represents stratigraphically the Keisley Limestone is identical with the fauna of the latter, his conclusions will rest on a firmer basis. Moreover, in order to demonstrate that the theory of discontinuous distribution is untenable, Mr. Marr must be able to prove the general distribution of the peculiar Keisley Limestone fauna over the intervening areas; otherwise he must acknowledge that some special local biological or physical conditions contributed to the congregation of this fauna in isolated colonies. Modern instances of discontinuous distribution with stations of limited superficial area admittedly offer problems hard to solve, but we cannot shut our eyes to their existence; and there is no *a priori* reason why similar instances should not be discovered in the records of the past, though naturally the difficulties of fully explaining them would be increased in dealing with extinct species.

It is needless here to recapitulate my reasons for drawing my conclusions as to the nature of the Keisley Limestone fauna; some of the less important ones are quoted and discussed by Mr. Marr, but the more important detailed palæontological evidence which he omits can be studied in my papers (Q.J.G.S., vol. lii, 1896, pp. 407–437, and vol. liii, 1897, pp. 67–106). When Mr. Marr sees fit to produce satisfactory palæontological proofs in support of his views as to the Keisley Limestone I shall be quite prepared to modify mine, but until then I see no reason that certain features of physical structure capable of other explanations should be considered sufficient to nullify the evidence of the organic remains; and accordingly I maintain that the Keisley Limestone cannot be brought forward as an illustration of Mr. Marr's theory of the formation of knoll-reefs, whatever may be the value of that theory in other areas. F. R. C. Reed.

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[1] See GEOL. MAG., 1897, pp. 420 and 468.

October 10, 1899.

OBITUARY.

GEORGE DOWKER, F.G.S.

Born April 2, 1828. Died September 22, 1899.

This well-known Kentish Geologist, Botanist, and Archæologist, passed away at Ramsgate on the very day of his return from the Meeting of the British Association. He was born on April 2, 1828, at Stourmouth House, Stourmouth, the home of his father, James Dowker, and was educated at Sandwich Grammar School; he afterwards studied farming at Hoddesdon Agricultural College, and at the age of 30 farmed his own estates. It is probable that an early love for botany was due to his schoolmaster, the Rev. J. Layton, and it is certain that a warm friendship with William Whitaker turned his attention seriously to geology. He was a good antiquary and contributed numerous papers to *Archæologia Cantiana*, chiefly dealing with Richborough, Reculvers, Wingham, and Preston Roman remains, and with the Anglo-Saxon cemetery at Wickhambreaux. His botanical researches are mainly contained in "The Flora of Kent," edited by Hanbury & Marshall, and his geology found expression in the following papers: "On Tertiary Strata at Bekesbourne," "Water Supply of East Kent," "On the Junction of the Tertiaries and the Chalk," "Chalk of Thanet," "On the Mouth of the River Stour."

Dowker was a good microscopist and was well acquainted with the pond life of his district. He was President of the Margate Microscopical Club, a prominent member of the East Kent Natural History Society, and was its President for several years. He paid special attention to coast erosion, and contributed a paper on the subject to the last meeting of the British Association, while one on Dungeness formed the subject of a recent lecture to the Geologists' Association of London. Dowker was a good draughtsman; his fossils found a home some years ago in the Maidstone Museum, but he leaves a valuable local herbarium. He was a F.G.S. for thirty-five years, and a member of the Dover Antiquarian Society. He leaves a widow and nine children to mourn his personal loss; but his death deprives Thanet, and indeed Kent, of an energetic and devoted servant of science, of a type only too rare in his district.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VI.

No. XII.—DECEMBER, 1899.

ORIGINAL ARTICLES.

I.—A NOTE ON THE GEOLOGY OF SOCOTRA AND ABD-EL-KURI.

By J. W. GREGORY, D.Sc., F.G.S., of the British Museum (Natural History).

THE first account of the geology of Socotra we owe to Lieutenant J. R. Wellsted,[1] who compiled the Admiralty chart and map, and in 1835 described the island in a detailed memoir, in which he showed that it consists of a mass of granite capped by limestones. Nothing material was added to this description until 1883, when Professor Bonney published his account[2] of the extensive rock collection made by Professor J. B. Balfour during a six weeks' visit to the island in February and March, 1879. Professor Bonney's study of the rock specimens enables him to prove that Socotra consists of a block of Archean rocks covered in places by massive limestones, which, on the evidence of their foraminifera, Professor T. R. Jones suggested were probably of Miocene age. It was further shown that both the Archean series and the Cainozoic limestones are cut through by dykes of trachyte and basalt, associated with a series of rhyolitic lavas. Professor Balfour's expedition not only proved that the foundations of Socotra are built of old materials, but that the island is of considerable antiquity, as is indicated by its rich endemic flora.[3]

In 1880 Socotra was visited by Emil Riebeck, who collected some rock specimens containing the mineral which was described in 1888 by Sauer under the name of Riebeckite.[4] Further details regarding the Archean and volcanic rocks were given in the same year in a paper by Miss Raisin.[5]

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[1] J. R. Wellsted, "Memoir on the Island of Socotra": Journ. Roy. Geogr. Soc., vol. v (1835), pp. 129–229, and map.

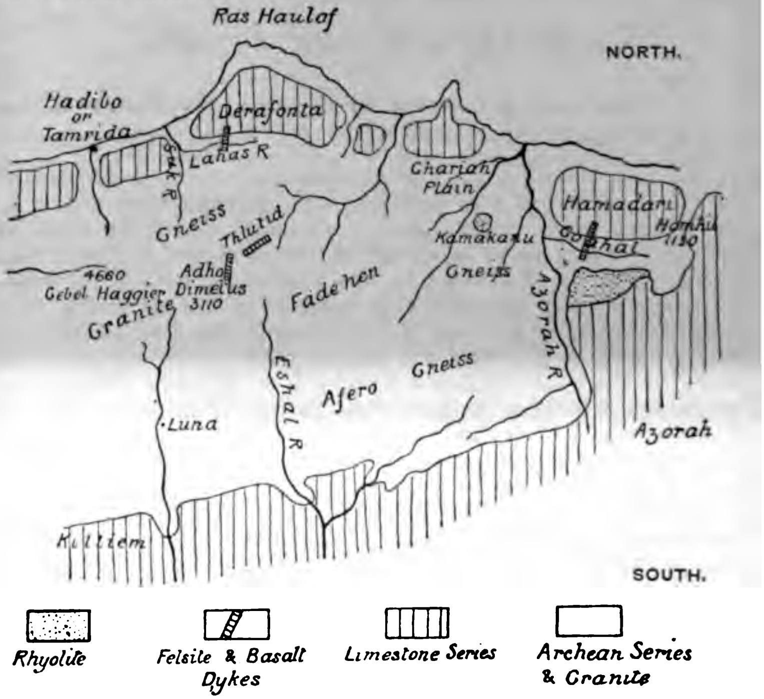
[2] T. G. Bonney, "On a Collection of Rock Specimens from the Island of Socotra": Phil. Trans., vol. 174 (1883), pp. 273–294, pls. vi and vii. Some preliminary remarks on the geology of the island were included in Professor Balfour's report, "On the Island of Socotra": Rep. Brit. Assoc., 1881, p. 486.

[3] According to Balfour ("Botany of Socotra": Trans. Roy. Soc. Edinb., vol. xxxi, 1888, p. lxxv) the island has been a land area since the Permo-Carboniferous, and "an island certainly from Tertiary times."

[4] Sauer, "Ueber Riebeckit, ein neues Glied der Hornblendegruppe": Zeit. deut. geol. Ges., vol. xl (1888), pp. 138–146.

[5] C. A. Raisin, "Rock Specimens from Socotra": GEOL. MAG., Dec. III, Vol. V (1888), pp. 504–7.

During last winter Socotra and the neighbouring island of Abd-el-Kuri were visited by Dr. H. O. Forbes and Mr. Ogilvie Grant, who made a collection of rocks, upon which I have been asked to report. Dr. Forbes has given me an account of the mode of occurrence and distribution of the principal rocks. At about the same time both islands were visited by the Austrian South Arabian Expedition in the "Gottfried," and a note on their geology has been published by Dr. F. Kossmat, in which he remarks the occurrence of Cenomanian and Eocene limestones.[1]



GEOLOGICAL SKETCH MAP OF NORTH-CENTRAL SOCOTRA.

The present collection does not necessitate any modification in the geological history of Socotra, as deciphered by Professor Bonney from the materials available in 1883. But the collection adds to the knowledge of the distribution of the different rocks in the island.

1. SOCOTRA.

The rock-collection from Socotra contains representatives of three groups of rocks—a basal Archean series, some massive limestones, and some comparatively recent volcanic rocks.

The largest part of the collection consists of Archean rocks and some associated granites. As a rule the gneiss is more granitoid than the rock which forms the main mass of the East African Archean plateau; but a specimen from Thlutid, at the height of 900 feet, corresponds with the typical gneiss of the mainland. With the granitoid gneiss there is a coarse pink granite which forms the summit of Gebel Haggier, the highest peak in Socotra; it occurs also at Adho Dimellus, and at the height of 1500 feet at Fadehen.

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[1] F. Kossmat: Sitz. math. nat. Cl. k. Akad. Wiss. Wien, 1899, No. ix, pp. 73–82.

The second group of the Archean series consists of dark-green amphibolite schists, of the type that forms such a conspicuous feature in the East African gneiss series. This rock was collected by Dr. Forbes in the Hadibo Plain near Tamrida.

The Archean rocks of Socotra therefore resemble those of the East African Nyika series, and the island is simply an outlier of the East African plateau.

Overlying the gneisses is a compact, massive limestone which has been sometimes rendered coarsely crystalline, probably by contact metamorphism. This limestone forms the extensive plateau at the eastern end of the island, and according to Dr. Forbes sections cut by the Goahal river show that the limestone there rests directly on the Archean series. South of the Goahal river the limestone forms a plateau, the southern end of which is continued westward round the southern flanks of the central highlands. From the Hamadari plateau a belt of limestone extends westward to beyond Tamrida; the rivers have cut through it, showing that it rests on the Archean series.

The collection gives no evidence as to the age of the limestones, but fortunately Herr Kossmat has obtained from it a number of mollusca and echinids, which enabled him to determine it as Eocene. Kossmat also records an underlying Cenomanian sandstone with *Janira quinquecostata.*

The last group of rocks represented in the collection is a series of recent volcanic rocks, of types already described from Socotra by Professor Bonney and Miss Raisin.

The volcanic rocks include rhyolites, quartz-felsites, and basalt. Most of the specimens are dyke rocks, but one lava is included in the collection. It is a rhyolite with well-marked fluxion structure and containing many angular fragments; it was collected on the edge of the plateau, south of the Goahal river. A similar rock has been described and figured by Professor Bonney[1] from Azorah, and according to Dr. Forbes the rounded hill in the Ghariah Plain near Kamakanu consists of the same rhyolite.

Quartz-felsites were collected from dykes intrusive in the Archean series at Homhil and Adho Dimellus. The felsites at both localities are intensely altered by decomposition; the abundant iron-ores have been altered to leucoxene, and the matrix is stained bright red. The only unaltered minerals are the large phenocrysts of quartz; and they are deeply corroded, as illustrated by Velain[2] from the quartz-trachytes of Aden, and by Miss Raisin[3] in a quartz-felsite from Socotra.

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[1] Bonney: op. cit., p. 287, pl. vii, fig. 5.

[2] Ch. Velain: "Descript. géol. presqu'île d'Aden," 1878, p. 18, fig. 2.

[3] Raisin: op. cit., p. 505, fig. 1.

In one case the quartz shows a zonal arrangement of the inclusions, a feature unusual in volcanic quartz crystals; but the identification of the mineral was confirmed by the use of convergent polarized light. The felsite from Adho Dimellus has numerous, somewhat ill-defined spherulites; in that from Hombil some of the smaller patches of secondary quartz are traversed by faint lines like cleavages, suggesting that the quartz has been formed by the alteration of tridymite aggregates.

The last member of the rhyolite-felsite series is an altered, fine-grained trachyte from the Ghariah Plain. It is similar in character to the trachyte figured by Professor Bonney[1] from the Azorah district.

A dyke of a fairly fresh basalt was found by Dr. Forbes at Thlutid, on the north-west slope of the granite mass of Adho Dimellus.

The most interesting feature in the trachyte and felsite is that the rocks resemble those of the Aden volcanic series rather than those of the East African volcanic group. For opportunities of examining some of the Aden rocks I am indebted to Mr. G. T. Prior.

Hence Socotra appears to be an outlier of the Somali plateau, which has been involved in the movements which formed the Gulf of Aden, and has been the scene of the eruption of volcanic rocks of the Aden series.

2. ABD-EL-KURI.

West of Socotra is the small island of Abd-el-Kuri, where a larger rock collection was made by Messrs. Forbes and Grant. It was also visited by Dr. Kossmat, who has described it as composed of amphibolites, penetrated by a network of granites and camptonite dykes, and capped by a limestone which he suggests to be of Turonian age. The only previous geological account of the island known to me is by H. J. Carter,[2] who in his memoir on the geology of the south-east coast of Arabia described Abd-el-Kuri as composed of a mass of granite and diorite, capped by a limestone which reaches to the summit at the level of 1600 feet above the sea.

The collection from Abd-el-Kuri is composed mainly of rocks belonging to the Archean series. They include a series of amphibolite schists, a syenitic gneiss, some specimens of which have a considerable development of epidote, and a white gneiss with hornblende aggregations: the last rock is strikingly like one which is common in the Ulu Mountains of Ukambani in British East Africa. This series of foliated rocks is cut through by pegmatite dykes, which are almost as coarse in grain as those of Somaliland: in one specimen collected the muscovite occurs in crystals from two to three inches in diameter.

The Archean rocks are covered by limestones which occur at different levels from 40 feet above the sea to the summits of Gebel

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[1] Bonney: op. cit., p. 287, pl. vii, fig. 6.

[2] "Geol. Papers on Western India," 1857, p. 620. On p. 621 of the same work Carter describes 'The Brothers,' the islets between Socotra and Abd-el-Kuri, as also formed of granite and diorite capped by limestone.

Saleh and Gebel Somali, the highest peaks in the island. The limestones appear to be very fossiliferous, and one specimen is crowded with shell fragments; but the only specimen generically determinable is a *Nerinæa* in a block of limestone collected by Dr. Forbes at the height of 700 feet. The limestone at that point is therefore no doubt Cretaceous.

On the lower parts of the island a reef limestone occurs up to a height of 40 feet above sea-level. As it contains well-preserved specimens of *Goniastræa retiformis*, it is no doubt of Pleistocene age.

II.—Notes on some Hardanger Lakes.

By Horace W. Monckton, F.L.S., F.G.S.

In many places in Western Norway we find a lake separated from a fjord by a mile or so of sand and gravel. Looking from the fjord, we see in such a case a series of step terraces, with possibly a high mound at the back, forming a dam at the end of the lake.

Several examples of this arrangement were mentioned by Amund Helland in a paper published by the Geological Society in 1877,[1] and he adopts the explanation suggested by S. A. Sexe,[2] that the dam at the end of the lake is a moraine formed when a glacier filled the space now occupied by the lake; in short, that it is the terminal moraine of a glacier which must have halted for some time at the point during the retreat of the ice, and consequently these mounds and terraces were formed at the close of or after the Glacial Period, for any advance of the ice beyond their site in the valleys would have carried them away to a greater or less extent.

During visits to Norway in 1896, 1898, and 1899, I have explored several of the valleys in which these moraines occur, and I think the following notes may be of interest.

I will first describe a side valley which branches off south from the great valley of the Hardanger Fjord, between 80 and 90 miles from the open sea. It is a deep channel carved out of gneiss, and the sides have in many places been scored and smoothed by ice, and these smoothed rock-sides pass behind all the deposits in the valley, showing that it is older than them all; in this it differs from many of our English valleys, that of the Thames for instance, where we believe that the valley is more recent than the drift around it and that the gravels in the valley mark stages in its excavation.

The mouth of the branch of the Hardanger Fjord valley of which I am speaking is at Vik i Eidfjord, and it has been filled up with gravel, sand, etc., almost to the edge of the main valley, so that there is but a small bay or indent in the fjord at its mouth.

From the fjord one sees a series of step terraces rising one above the other, the highest being on the east side with a flat top and of considerable extent.

If we follow the river up from its mouth we find that it has cut a channel through all the terraces, which look like great railway embankments on either side, and rather more than a mile from the fjord we reach a lake, the Eidfjord Vand. Its depth is 246 feet, the surface is 56 feet above the sea, and the bottom is therefore 190 feet below the surface of the fjord. These figures are from a paper by Amund Helland;[1] in other cases I have done my best to obtain accurate figures, but have sometimes had to rely on my pocket aneroid.

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[1] Quart. Journ. Geol. Soc., vol. xxxiii, p. 142.

[2] "Mærker eften en Iistid"; 4to; Christiania, 1866.

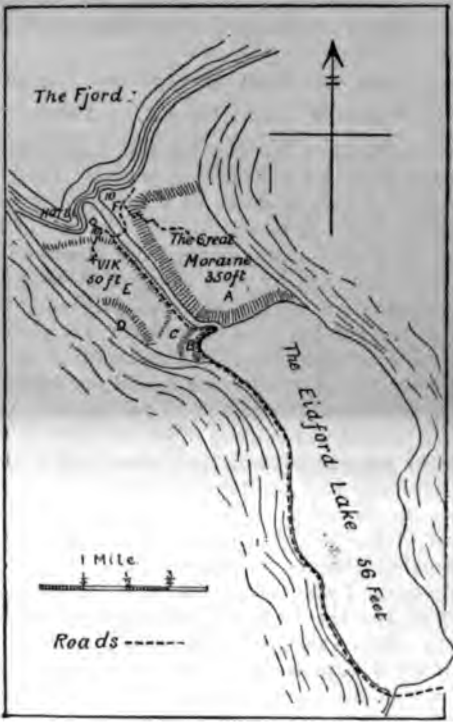

FIG. 1.—SKETCH MAP OF VIK I EIDFJORD.

A, the great moraine on the east of the river; B, the portion of the great moraine on the west of the river; C, space of bare rock to seaward of the great moraine; D, the shelf, probably a fragment of the great moraine; E, the terrace upon which Vik i Eidfjord Church stands; F, the 10 feet terrace upon which the hotels stand.

On looking at the map (Fig. 1) it is clear that almost the whole of the material of which all these terraces are formed must have come down the valley and over the lake, the length of which is 2½ miles, and it must consequently have been brought whilst the ice had possession of the lake.

The highest terrace is on the east side of the valley, and if we mount to its top we find ourselves on a large plain, say one mile long and half a mile wide, with a slight slope to the sea. It extends from the lake nearly to the fjord, and is bounded on the east by the steep rocky side of the valley and on the west by a deep channel cut by the river which flows from the lake to the fjord. On the top there is a village and fields.

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[1] "Dybderne i nogle indsjöer," etc.: Norges. Geol. Undersøgel, 1894, p. 93.

The flat top shows that the sand, gravel, and stones of which this vast mound consists must have been spread out under water, no doubt the water of the sea. Its height is about 350 feet above the sea, so that at the time of its deposition the land must have stood at least 350 feet lower than now.

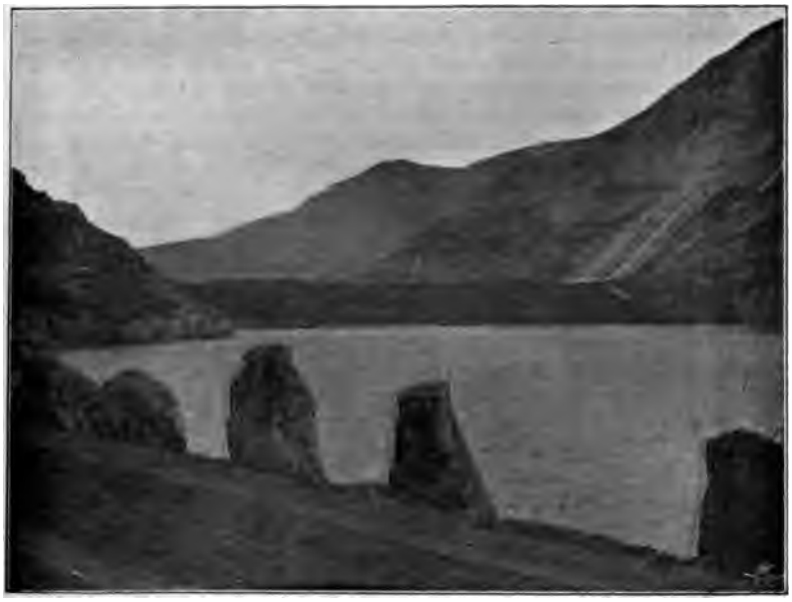

FIG. 2.—THE EIDFJORD VAND, VIK I EIDFJORD, HARDANGER.

The moraine on the west side of the river is not so large. Its top is more rounded and not quite so high. Its highest point is near the west side of the valley, and from it I could see the houses on the great moraine opposite, so that the difference in level is not large. The north end of the lake, with the great moraine, is shown in the photograph, Fig. 2, which was taken from the road on the west of the lake. On the whole, it seems to me probable that the bank originally stretched across the valley at about the same height, and that the present difference in level is due to the erosion effected by waters flowing down the valley. At what period in this erosive process the ice left the site of the lake is not quite clear, but that it must have been at a fairly early period is shown by certain step terraces at the southern or upper end of the lake and by old shore-lines on the great moraine itself.

There are two fairly well-marked shore-lines on the lake face of the moraine, one about 100 feet above the surface and the other rather lower. These no doubt mark stages in the deepening of the outlet by which the river flows to the sea: probably the deepening of the outlet bore some relation to the rise of the land. On the west of the outlet there is a working for gravel on the inner face of the moraine, and it shows ordinary moraine stuff—sand, gravel, and stones of all sizes, mixed loosely together.

There is a rough stratification parallel to the face of the bank, as though material had been carried off the top and rolled down the face of the moraine towards the lake, and this makes me suspect that the ice had left the face of the moraine whilst it was still submerged beneath the sea. At the top of the pit there is a little blue stratified clay. It is about 50 feet above the lake, and I saw in 1899 a small section in a similar blue clay by the roadside near the western end of the moraine, about 15 feet above the lake. The section was about 2½ feet deep, and exposed stiff blue clay well stratified with a layer or two of ferruginous deposit. These clay deposits show that the level of the lake was lowered very gradually.

Passing now to the south end of the lake, we find an alluvial flat of considerable extent, on which the village of Sæbö stands, and above the flat are some step terraces up to a level of perhaps 200 feet. These terraces clearly cannot have been formed when the glacier extended down the valley beyond them, and they are flat and have obviously been deposited under water—the water of the lake. They therefore belong to the period when the ice had left the lake and when the water of the lake stood at least 144 feet higher than now; in other words, before the river had cut down its outlet to a depth of more than 207 feet below the top of the highest terrace. Taking this together with the evidence furnished at the moraine end of the lake, I am led to suspect that the glacier left the lake during an early part of this cutting-out process.

Two valleys meet at Sæbö, and in both we find moraines and terraces. The western valley is Hjalmodal, and near its mouth there is a moraine of great blocks reaching a height of over 300 feet above the sea, and also a fairly flat-topped moraine at a rather lower level. The eastern valley eventually leads up to the celebrated Vöringsfos. At the lower end above Sæbö a knob of rock stands out, or rather did stand out, in the middle of the valley, and the space between it and the valley wall is filled in with moraine stuff to a height of some 200 feet above the river. Small sections show that this is in part stratified sand. The River Bjoreia flows round the other side of the knob, and above the river are small terraces.

A little further up the valley a sandy flat seems to mark the site of a small lake; terraces occur on both sides, and probably once formed a barrier across the valley when the glacier occupied it as far down as this point. The river has now removed much of this barrier, and the lake is dry.

I now return to Vik i Eidfjord and the step terraces between the fjord and the great moraines. They are confined almost to the west side of the river, of which the part between the lake and the fjord is named the River Eieo, almost all the east side being occupied by the high moraine. The river and terraces are seen in the photograph, Fig. 3. The most extensive terrace is the flat upon which the church and village of Vik stand. It is about 50 feet above the fjord and rises inland. Below it there is a smaller flat, say 10 feet above the fjord, on which the Hotel Vöringsfos stands, and still lower there is a fair extent of flat at the present level of the river. Each of these flats must mark pauses in the elevation of the land, and, as I have suggested above, the river probably cut its channel through the moraine deeper in proportion as the land rose.

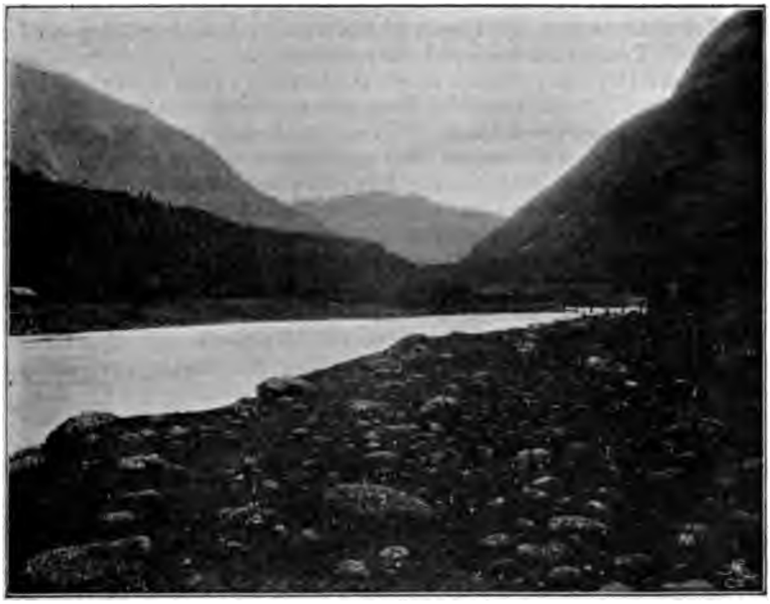

FIG. 3.—VIEW FROM THE MOUTH OF THE RIVER EIEO, VIK I EIDFJORD.

As I have shown that the ice left the lake at any rate before the channel had been excavated to anything like its present depth, and as all the material of which these terraces are formed must have been brought across the lake at the same time as that of which the highest terrace is formed, I am inclined to think that originally the highest terrace filled the whole valley from side to side and from the lake to the fjord, and that the step terraces are not formed by subsequent deposition but have been carved out of it by river erosion.

My reasons for this conclusion are as follows:—

At the seaward side of the moraine on the west of the river there is a space where bare rock is exposed practically from the river to the side of the valley (Fig. 1, C), but nearer the fjord there is a prominent ledge or shelf (Fig. 1, D) of moraine stuff with a flat top nearly as high as the corresponding part of the highest terrace on the other side of the valley. I think this must be a fragment of the highest terrace, and if so shows that it extended a long way down the west side of the valley.

Again, close to Vik Church there is an oblong mound running north and south; the top is flat and 67 yards long, and its height perhaps 40 feet. My attention was drawn to it by Herr Næsheim, the proprietor of the Hotel Vöringsfos, and at first I was at a loss to account for it. I now think it is a fragment of a higher terrace, which has been left by the river when it cut down to the church flat.

At the present time, too, the river is carving out a terrace at sea-level and throwing the material removed from its banks into the fjord, forming a vast spoil heap which, owing to the great depth of the fjord, is only now beginning to project slightly.

Helland remarks: "Near to where the river issues from the lake the solid rock protrudes, being here covered with groovings. Thus the lake is a true rock-basin."[1] This no doubt refers to the spot already mentioned where, on the west of the valley, rock extends nearly as far down as the river, but there is a space of about half a mile between this rock and the eastern face of the valley, which is covered by moraine. I therefore see nothing to show that the bottom of the old valley is not buried under this moraine, and would observe that the course taken by the overflow from the lake over the top of the moraine could have no reference to the shape of the bottom of the rock valley beneath. I suspect that if all the moraine stuff were removed the Eidfjord Vand would prove to be an arm of the Hardanger Fjord.

Some thirteen miles west of Vik a long arm runs south from the Hardanger. It is the Sör Fjord, and at its head we find many of the features described above repeated. There are again step terraces, on one of which stands Odda, and there is a vast moraine forming a dam to a lake—the Sandven Vand. The moraine attains a height of 446 feet above sea-level. The top is not flat, but forms a mound, its shape being, as Helland suggests, probably due to the fact that its top stood above the sea-level at the time of its deposition. Below there is a large flat terrace at a level of about 308 feet above the fjord.

The step of the terrace on which the school at Odda stands has a slight slope away from the fjord, the result of the manner in which the river has carved it out; and in cutting out the lowest terrace, the river has left a bank projecting from the next step between the lowest terrace and the fjord, which, until I realized that these terraces were cut out, somewhat puzzled me.

We will now cross to the north of the Hardanger Fjord and glance at the Graven Fjord, with its lake, the Graven Vand. That lake is a mile from the fjord. Its level is 95 feet above the sea and it is 282 feet deep. At the head of the fjord there is a large flat with a long slope under water, which is in process of extension by the present action of the river. This flat extends for some distance inland, and on the east reaches the side of the valley. On the west there are terraces at varying levels, and in one of them there is an unusually good section, of which I took the photograph, Fig. 4.

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[1] Loc. cit., p. 166.

The height of the section is about 30 feet. It shows typical moraine stuff very well stratified. In the lower part are some fair-sized boulders in a bed of sand, and they stand out and produce a sort of earth-pillar structure. I could not find a trace of shells. The bottom of the section is about 10 feet above the fjord. Between the fjord and the lake are mounds and terraces, and near the end of the lake there is a flat-topped terrace which may once have crossed the valley, but now the river flows with a fairly even slope from the lake to the fjord.

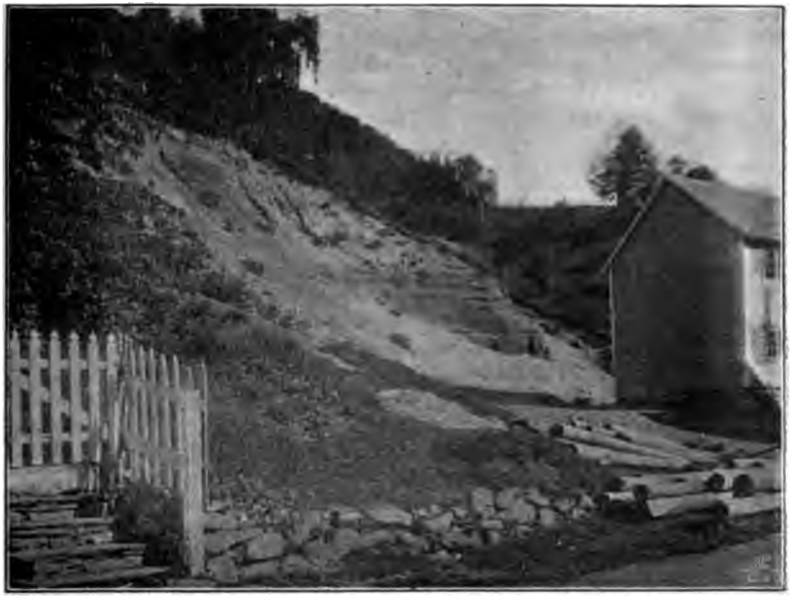

FIG. 4.—SECTION IN A SAND-PIT NEAR THE LANDING-PLACE, EIDE, GRAVEN FJORD, HARDANGER.

Above the Graven Vand there are extensive terraces, one or two of which, I believe, are old moraines of which the top has been flattened artificially. There are others which mark old water-levels, and in one by the roadside at a stone 20 kilometres from Voss there is a good section showing well-stratified sand with a few stones. There is a fairly extensive flat at a level of 30 feet above the lake and a smaller terrace 10 feet higher. In it I saw the following section:—

SECTION IN FLAT-TOPPED TERRACE, SEIM I GRAVEN.

1. Earth, 9 inches.
2. Stones of various sizes, with little or no sign of stratification.
3. Coarse sand, well stratified and showing current bedding; 4½ feet seen.

I imagine that these flats and terraces mark former levels of the fjord. There is no evidence that either the Sandven Vand or Graven Vand are rock basins, but in conclusion I will say a few words about a lake which I am inclined to think is a rock basin, though I could not prove this for certain without boring. I refer to the lake at Noreimsund on the north side of the Hardanger Fjord.

The outlet of the lake reminds one of the outlet of Loch Etive, near Oban, but it is on a much smaller scale and is the best example of its kind I have seen. The water flows over a rock-lip, the whole of which from shore to shore is perfectly clear. At high-tide the lake becomes, in fact, the end of the fjord, whereas at low-tide a stream pours over the rock and forms a small cataract. There is one place, about a hundred yards west of the outlet, where rock does not show at the surface of the ground, and where there may possibly be a buried channel passing to the fjord behind the village. In any case the locality is interesting and well worth a visit.

III.—A CONTRIBUTION TO THE DISCUSSION ON ROCK-WEATHERING AND SERPENTINIZATION.

By T. H. HOLLAND, Officiating Superintendent, Geological Survey of India.

BY correlating the head and the tail of Professor G. P. Merrill's "Discussion on the use of the terms Rock-weathering, Serpentinization, and Hydrometamorphism,"[1] I infer a direct invitation to confer with him on the questions raised by me at the Bristol meeting of the British Association.[2]

At the outset it should be explained that, though not so apparent from the published abstract, reference to the full text of my paper as read shows that Professor Merrill and I have on many points independently arrived at similar conclusions.

In his "Treatise on Rocks and Rock-weathering," Professor Merrill called attention to the not unfrequent omission in geological literature of a precise distinction between the work of subaërial agents and the deep-seated forms of hydrometamorphism and alteration. But although he included "epidote, chlorite, sericite, leucoxene, kaolin (?), pyrite, and various zeolitic compounds" in the latter category, he made no mention of serpentine. Professor Merrill says that the distinction drawn by him in 1897 between weathering and the more deep-seated alteration of rocks is essentially that made by Roth between *Verwitterung* and *complicirte Verwitterung*.[3] He also now says that whilst Roth in 1869 spoke of serpentine and zeolites as products of weathering (*Verwitterung*), he so far changed his views or mode of expressing them in his latest work (1893) as to call the deep-seated process *complicirte Verwitterung* in distinction from the purely superficial *Verwitterung* due to atmospheric action.

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[1] GEOL. MAG., August, 1899, pp. 354–8.

[2] "The Comparative Actions of Subaërial and Submarine Agents in Rock Decomposition": Rep. Brit. Assoc., 1898, p. 868; GEOL. MAG., January, 1899, p. 30.

[3] "Rocks and Rock-weathering," pp. 161 and 174 (footnote).

These are by no means the impressions I have gathered from Roth's writings, in which I can find no change of views between 1869 and 1893, and nowhere any consolation either for my views of the origin of serpentine or of Professor Merrill's modification of them. Roth[1] distinguished *einfache Verwitterung*—the simple chemical reactions produced in rocks by the action of atmospheric air, water, and the contained gases—from *complicirte Verwitterung*, which is due to the complex reactions of solutions formed by the first process. By the use of the term *complicirte Verwitterung* Roth merely referred to the complex nature of the chemical reactions, and never suggested that the water of these solutions was other than of immediate superficial origin. The action of superheated water, steam and other vapours from deep-seated sources, Roth distinguished under quite a different name as *Zersetzung*, which is unfortunately the term *decomposition* by which Professor Merrill proposes to distinguish true weathering from the more deep-seated *alteration* and *hydrometamorphism*.[2]

Moreover, although it is true, as Professor Merrill says, that Roth in his "Ueber den Serpentin" described the processes and results incidental to the *Verwitterung* of the serpentine quite independently of those incidental to its first production, he did not recognize any essential difference between them; but, on the contrary, says expressly, "die Verwitterung des Olivins zu Serpentin nur ein Stadium des Prozesses bezeichnet, der Serpentin unterliegt seinerseits einer weiteren Verwitterung."[3] Roth evidently considered serpentinization to be induced by meteoric waters, and referred definitely to the oxidation as a phase of the process. Both in his first volume, which appeared in 1879 (p. 113), and in the last volume of his "Chemische Geologie" (1893, p. 422), he refers to the serpentinization of olivine under the heading "Einfache Verwitterung des Olivins." On this account, coupled with the acquiescence by silence or applause on the part of English writers, I brought the new facts obtained in India to the notice of the British Association, and concluded therefrom that atmospheric agents had practically nothing to do with the formation of serpentine rock. On the same occasion, by comparing the geological history of the Madras Presidency, where fresh olivine rocks occur abundantly, with that of the Andaman Islands, Kashmir, and Baluchistan, where our serpentines are found, it was suggested, as a basis for discussion, that submergence below sea-level favours the formation of serpentine.

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[1] Allgemeine und Chem. Geol., vol. i (1879), pp. 1, 2, 43, 47, and 159.

[2] As results of *complicirte Verwitterung* Roth included the zeolites and many of the minerals considered by Professor Merrill to be due to agents of deep-seated origin. I agree with Professor Merrill's list (serpentine not being on it), but I see no support for our views in the writings of Roth. His later use of the expression agrees exactly with the statements made in earlier papers, where the verb is not given an adjectival form, as in "complicirt sich die Verwitterung des Felsitporphyrs durch Zufuhr von Kalk und Eisen aus nahe gelegenen Partien, so entstehen 'Epidosite' Gesteine" (Abhand. der Akad. der Wiss., Berlin, 1869, ii, 133).

[3] Abhand. der Akad. der Wiss., Berlin, 1869, ii, 345 and 346.

Professor Merrill has now advanced further evidence in support of my first point by showing that there are essential chemical differences between serpentine and the weathered products of magnesian rocks.[1] Although, however, we are agreed, Professor Merrill and I, that serpentine, as one instance of a secondary hydrous mineral, has been wrongly ascribed to weathering, we find ourselves at variance when we pass from destructive criticism to the creation of a more satisfactory substitute for the old ideas.

As the presentation of objections to an opponent is generally an easier problem than proving one's own case, I will commence with a criticism of Professor Merrill's theory. According to his view, "serpentinization is a deep-seated process[2] due to waters or vapours coming from considerable depths, and it may be even constituents of the magmas at the time of their intrusion." "The almost complete absence of oxidization products in fresh serpentine is," he says, "indicative of this."[3]

This last clause, given as a reason for the conclusions indicated in the previous part of the same paragraph, is the one which I would first of all criticize, and against which I will produce, besides the statements of Roth, the testimony of a very reliable authority to show that oxidation is a constant, and presumably essential, phase in the formation of serpentine from olivine:—

"The serpentinous alteration [of olivine] takes place along the irregular curvilinear lines of fracture, and under favourable conditions continues until the transformation is complete. . . . . The iron, which existed as protoxide, is further oxidized, and crystallizes out along lines of fracture as magnetite or hematite, or in the hydrous sesquioxide form known as limonite."

"In this process of hydration the combined iron becomes converted into the sesquioxide form."

"The mineral olivine, an anhydrous ferruginous silicate of magnesia, passes over into serpentine by a simple process of hydration, and a more or less complete change of its combined iron from the ferrous to the ferric state."

So we learn from the fascinating "Treatise on Rocks and Rock-weathering."[4] And in this matter its author is in perfect agreement with other earlier authorities. The limited amount of oxidation may be claimed to be as consistent with the submarine as the subterranean theory, but as it is not part of the evidence on which I base the former it may be left out of the present argument.

"The action of waters or vapours coming from considerable depths" has often been referred to by earlier writers as the cause of certain alterations amongst the secondary minerals mentioned by Professor Merrill.[1] The formation of zeolites by the action of thermal springs in brickwork was, everybody knows, considered by Daubrée to be a sufficient explanation of the origin of the amygdales in volcanic rocks, and the same author suggested further that palagonite and serpentine were formed in a similar way.[2] Of the other secondary minerals, without going into the extensive literature which exists, it will be necessary only to recall the processes by which the formation of kaolin, epidote, chlorite, biotite, and magnetite has been traced out in detail by Professor Judd[3] in the propylites of the western isles of Scotland, as the result of solfataric action on previously fresh rocks of the andesitic and dioritic types, which are the oldest of the Tertiary eruptives in that area. Professor Judd carefully emphasizes a distinction between the widely-spread effects of solfataric action and the somewhat similar, but purely local, effects of contact-metamorphism.

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[1] That serpentine loses water by exposure to the weather is not in itself, however, a proof that the previous hydration of the olivine was not effected by atmospheric water. Laterite, which is unquestionably a product of true, though peculiar, weathering, loses water on exposure even to a humid atmosphere.

[2] W. Lindgren in 1896 also referred to serpentinization as a deep-seated process, which, he said, should not be referred to weathering: 17th Annual Report, U.S. Geol. Surv., pt. ii (1895-6), p. 92.

[3] Geol. Mag., August, 1899, p. 356.

[4] pp. 24, 25, 97, 158, and 159.

The other point raised by Professor Merrill, namely, the behaviour of the water and other vapours included in the magma, has not, I admit, been so generally recognized, and for that reason I have recently taken advantage of more than one opportunity of bringing the importance of this matter into prominence. In 1897 it was pointed out that the water excluded from the mother-liquor by the separation of anhydrous minerals from a basic aquo-igneous magma may attack the susceptible ferromagnesian silicates previously crystallized from the same magma, with the formation of secondary biotite and magnetite.[4] There are reasons for supposing that a similar explanation applies to the zeolites of the Deccan Trap in localities distant from any volcanic vent.[5]

But the idea, nevertheless, is not an original one; for although J. D. Dana[6] held in 1845 that amygdales were formed by the infiltration of water, probably sea-water, he expressed a modification of his views in 1880, stating "that the moisture which made the amygdaloidal cavities was the moisture which altered the pyroxene or other minerals of the rock to chlorite, and made the zeolites and quartz chiefly out of its felspars."[1] Scrope, even as far back as 1825, suggested that these secondary minerals in trap rocks are the results of vapours accompanying volcanic eruptions, though he admitted that additional material might subsequently be obtained by the infiltration of solutions from overlying rocks, especially "calcareous strata."[2] In 1897 Sir A. Geikie pointed out that though it is a common belief that the filling in of the steam cavities has taken place long subsequent to the volcanic period by the slow percolation of meteoric water through the rock, he believed that at least in some cases, if not all, the conversion of the vesicular lavas into amygdaloids was effected during the volcanic period, the amygdales themselves sharing in the general metamorphism induced by later eruptions.[3]

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[1] "Rocks and Rock-weathering," pp. 161 and 174 (footnote).

[2] Quart. Journ. Geol. Soc., vol. xxxiv (1878), p. 82.

[3] Quart. Journ. Geol. Soc., vol. xlvi (1890), pp. 341–382.

[4] "On Augite-diorites with Micropegmatite in Southern India": Quart. Journ. Geol. Soc., vol. liii (1897), p. 405.

[5] In a memoir on the Salem rocks, now in the press, evidence is given which indicates an origin similar to this for the magnesite which is so constantly found veining the peridotite masses in South India. Most, if not all, these peridotite eruptions are accompanied by masses of white quartz containing liquid carbonic acid. The association of these two rocks is too constant to be fortuitous, and is suggestive of a genetic relationship, the quartz being more probably the siliceous end-product of the eruption in each instance, and in the absence of alumina and alkalies consolidates as simple quartz instead of forming alumino-alkaline silicates. That being so, the large quantities of carbonic acid under pressure might attack the olivine, with formation of magnesite and separation of chalcedonic silica. The water associated with the carbonic acid accounts for the small quantities of picrolite always found in these peridotites, which, however, never show a general serpentinization of the mass.

[6] "Origin of the constituent and adventitious Minerals of Trap and the allied Rocks": Amer. Journ. Sci., vol. xlix (1845), pp. 49–64.

Although different opinions are recorded concerning the origin of certain of these secondary minerals, there is a fair agreement in literature with regard to the *possible* origin of secondary chlorite, biotite, epidote, magnetite, and the amygdaloidal bodies in basalts by the action of subterranean vapours, both during and subsequent to the consolidation of the rocks in which they occur. Although, moreover, more than one mode of origin has been granted for certain of these minerals, I cannot subscribe to Professor Merrill's verdict that "geologists and petrologists as a rule have been extremely careless in their use of such terms as *alteration*, *decomposition*, and *weathering*." Roth gave a wider meaning to weathering than most, but before, during, and since his time many of the minerals regarded by him as products of weathering have been referred to deep-seated agencies. Kaolin and, with evident misgivings, serpentine have, however, until recently been generally looked upon as the work of meteoric waters. After what has been written above and published in other papers, it would be difficult to prove that I entertain any predetermined bias against the action of deep-seated agencies. On the contrary, knowing what has been done in connection with epidote, chlorite, and the other secondary hydrous minerals just referred to, the first step to take, after abandoning the weathering theory, would most naturally be an examination of the possibility of serpentinization by deep-seated agencies.

The very facts, however, which indicate in India the insufficiency of weathering to account for serpentine masses, point to quite a different conclusion; and until these facts have been shown to be purely local and exceptional, or until they are proved to be necessary accompaniments of some more far-reaching cause, the submarine theory remains as the first and simplest inductive inference. Briefly the facts are these:—At different points in the old crystalline land area in the Madras Presidency, Mysore, and Coorg, we know of more than a dozen occurrences of peridotites, chiefly dunites, but not a single mass of serpentine. In the Andaman Islands, Burma, Kashmir, Baluchistan, and near the North-West frontier—areas which have been covered by Tertiary marine sediments—we know of about the same number of peridotite occurrences, which are all highly serpentinized. Fresh olivine is as scarce in the areas which have been submerged as serpentine is in the old crystalline block of Peninsular India, which has suffered uninterrupted subaërial denudation since at least Lower Palæozoic times. In the latter area it is not merely the dunites which have escaped hydration; the olivines of the basic dyke-rocks are equally fresh. If serpentinization is due, as Professor Merrill suggests, to waters or vapours coming from considerable depths, it is difficult to see why these rocks, erupted at different times and in well-separated localities in Peninsular India, should universally escape, whilst in the other areas mentioned, also widely separated by great distances, serpentinization should be so constant. With evidences of the action of deep-seated vapours in other ways in Peninsular India, the value of this point becomes accentuated. Besides olivine, other minerals, notably nepheline, are remarkably free of hydration in the Madras Presidency.

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[1] Amer. Journ. Sci., ser. III, vol. xx (1880), pp. 331-2.

[2] "Considerations on Volcanoes," 1825, pp. 126-7.

[3] "Ancient Volcanoes of Great Britain," 1897, vol. i, pp. 16, 17; vol. ii, p. 189.

It was pointed out at Bristol that whilst fresh peridotites occur in a moist warm climate exposed to heavy rainfall, serpentines are found in the dry deserts of Baluchistan, and Professor Merrill has now produced similar evidence from America to show that the distribution of serpentine and of unaltered olivine-rock does not coincide with any general difference of climate. On the other hand, the areas containing serpentine have been submerged below the sea, whilst those in which fresh peridotites occur, so far as we know, never have been. The first inference is obvious, and the next duty is to discover if these circumstances in India are merely local accidents or in general agreement with the evidence obtained in other parts of the world. For this we must await the testimony of geologists who possess the necessary local knowledge.

By his reference to the fresh condition of the olivine in the Corundum areas of western North Carolina, Professor Merrill cites a case which appears to be in agreement with our observations in India. The crystalline belt which runs N.E.–S.W. through North Carolina is one of the few persistent sturdy old blocks of crystalline rocks which have been unaffected by late earth movements.[1] It apparently formed the south-eastern boundary of the old Palæozoic seas, and suffered a marine trespass only on its eastern borders during the Mesozoic and Tertiary times.[2] The distribution of the marine sediments and the principal directions of folding indicate that this crystalline 'Scholle,' to quote Suess' terminology, presents to the Appalachians a relation similar to that holding between our Peninsular 'Vorland' and the Himalayas. Here we have the negative side of the argument — in an area not known to be submerged since the eruption of the peridotites no general serpentinization has occurred.

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[1] This belt has been the only serious rival with which Peninsular India has had to compete in the mica market, and the preservation of large sheets of delicate muscovite in coarse-grained pegmatite is generally a safe index of geological stability and quiescence.

[2] See Dana's "Manual of Geology," 4th ed. (1895), pp. 412, 443, 536, 633, 735, 813, and 881.

But the area mentioned by Professor Merrill offers positive evidence also in agreement with the facts detailed for India:—The peridotites of western North Carolina lie in a chain of such eruptions whose outcrops occur at irregular, but frequent intervals along a narrow belt, stretching from Tallapoosa County in eastern Central Alabama, on the south-west, to Trenton, New Jersey, on the north-east, whilst fewer outcrops are recorded further northwards in the states of Vermont, New York, Connecticut, Massachusetts, New Hampshire, and Maine. In a paper on the Chromite of North Carolina, Dr. J. H. Pratt,[1] referring to this belt of peridotites, says: "In North Carolina and in the more southern portions of this belt the prevailing rock is dunite, while in the northern portion the secondary rocks, serpentine and talc, are prominent." Now, it is in the region of North Carolina that the crystalline hiatus is widest, whilst as the belt is followed in the north-east direction, the Triassic, Cretaceous, and Tertiary sediments are seen to encroach on the crystalline rocks, and to converge to the old Palæozoic boundary of the Appalachians, until, in Maryland and New Jersey, there is fair evidence to show that the crystalline rocks have been submerged more than once since the commencement of Triassic times.[2]

As many of these peridotite intrusions are found in contact with crystalline rocks only, their precise geological age is not known. But this and the exact value of such evidence can be discussed with profit only by the geologists possessing the necessary local knowledge. This opportunity might be taken to subpœna the Scandinavian and Canadian geologists, who are familiar with old crystalline land areas. One knows through Brögger[3] of the remarkably fresh olivine-rock of Söndmöre in Norway, which is not apparently near any marine sediments, though suspiciously near the coast. The ophicalcites and serpentines of the old schists would naturally be excluded from this discussion, as they would involve questions of origin far more complicated than that of simple serpentinization. Still, even they are suspiciously associated with limestones.

Old serpentines are known in the Lake of the Woods and Rainy Lake areas of Canada to be older than the folding of the Keewatins (Lawson); with the Cambrian and Cambro-Silurian of the Eastern Townships of Quebec (Ells); and with altered volcanic rocks in the lower part of the Carboniferous of the Kamloops region (Dawson). But I can recall no instance of a distinctly eruptive peridotite in the portions of the old Canadian crystalline protaxis which are not covered by marine sediments. The Canadian geologists will be able to tell us whether such exist, and to what degree they have been altered. The crystalline rocks of Canada have also been cut by basic dykes, and it would be interesting to know if the olivine

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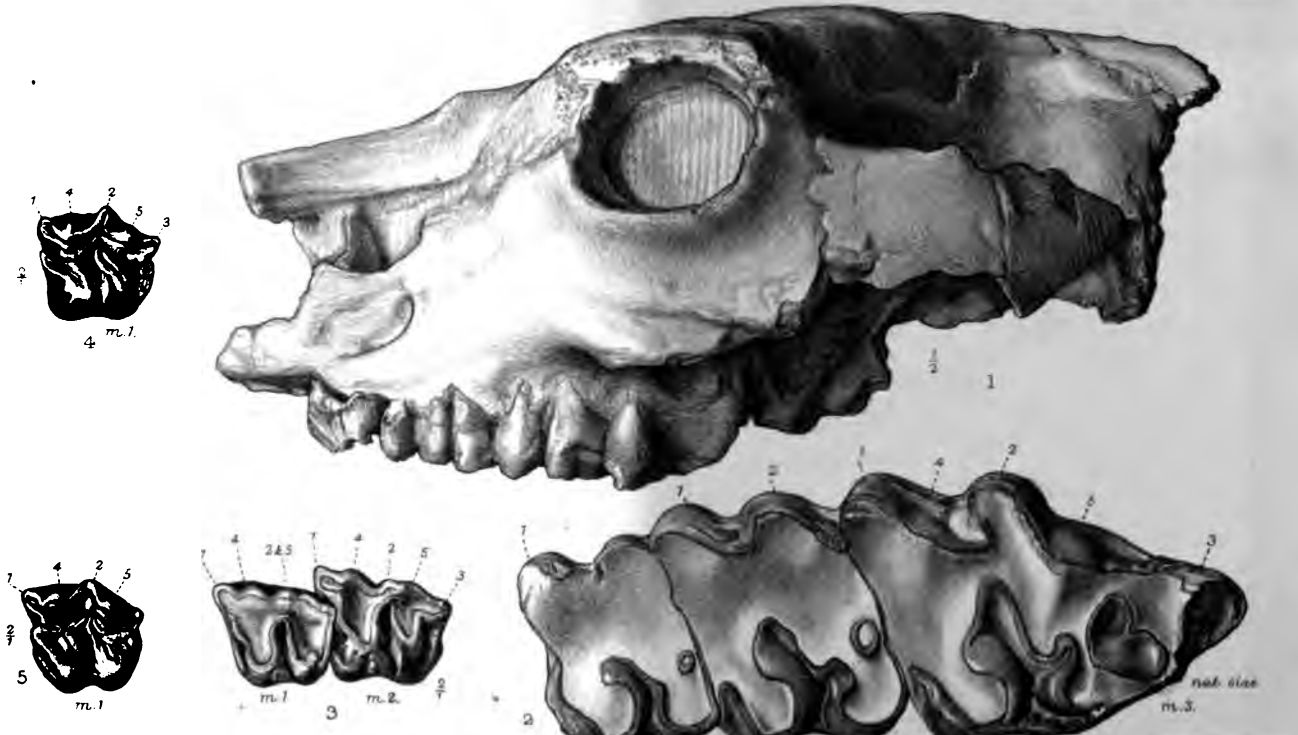
[1] Trans. Amer. Inst. Mining Engineers, Feb., 1899; see also literature therein quoted.

[2] See McGee's Geological Map of the United States, 1884.

[3] Neues Jahrb. f. Min., 1880, ii, pp. 187–192.



G.M. Woodward del et lith.

West, Newman imp.

Pliohyrax graecus (*Gaudry.*) Upper Miocene Samos.

crystals which occur in some of these are slightly or extensively serpentinized, and whether also the recently discovered nepheline-syenites of Ontario, which are old enough to be crushed and foliated, contain fresh or altered nepheline.

"Just what would be the effect of prolonged submergence in sea-water on a mass of olivine rock," Professor Merrill is not prepared to say. Neither am I. But I see no flagrant theoretical objection to serpentinization under such conditions. On the contrary, it is theoretically to be expected that sea-water, acting under high pressure, would permeate rocks to greater distances,[1] and, being charged with carbonic acid as well as salts of lime, magnesia, and the alkalies, would form a more destructive reagent than rain-water when in contact with unstable silicates.

It is easy to foresee many difficulties which must be met should the submarine theory attain a maturity that warrants deductive tests. At present it has not reached that stage; for although the evidences, both positive and negative, from India indicate that a submarine existence has formed part of the history of every mass of serpentine, it will require the testimony of other areas to show that such submarine conditions are *essential* for serpentinization on an extensive scale.

In conclusion, it should be stated that Professor Merrill's paper has drawn me into this discussion earlier than was anticipated. Although the question has been under consideration for some years, the facts, so far, at my disposal warrant no further deductions than those tentatively offered for discussion at the meeting of the British Association. Keeping in view the fact that a mineral may be produced by more than one of the ways into which we classify the processes going on in Nature, recent observations indicate a fairly definite classification of the *usual* conditions under which secondary hydrous minerals are produced. Until these are established with more certainty, however, the formulation and definition of precise general terms might profitably be replaced by the accumulation of details concerning the paragenesis of each mineral.

IV.—THE HYRACOID *PLIOHYRAX GRÆCUS* (GAUDRY) FROM THE UPPER MIOCENE OF SAMOS AND PIKERMI.

By C. I. FORSYTH MAJOR, M.D., F.Z.S.

(PLATE XXIV.)

AMONGST the hosts of Antelopes, Rhinoceroses, Hipparions, etc., which form the bulk of the Pikermi fauna described in Gaudry's classical "Animaux Fossiles et Géologie de l'Attique," the mandible of *Leptodon græcus*,[2] with lower molars recalling the Palæotheres and Paloplotheres, seemed to stand out, as it were, as an anachronism. It has always appeared to me, as it may also have to others, that the occurrence of such a type in the above company (with which

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[1] Cf. J. D. Dana, Amer. Journ. Sci., vol. xlix (1845), pp. 57 and 58.

[2] A. Gaudry: "Animaux Fossiles et Géologie de l'Attique," 1862, p. 215, pl. xxxiv, figs. 1, 2.

Orycteropus and the Ostrich are also associated, in the contemporary beds of Samos) might be accounted for in a satisfactory manner, if *Leptodon* could be shown to be related to the Hyraces. Against such a relationship is opposed the large heel of the *Leptodon's* last molar; so that an affinity with *Titanotherium*, as suggested by Schlosser and Von Zittel, seemed to be more probable.

The skull in the Geological Department of the British Museum (No. M 5,419), briefly noticed by me in last month's GEOLOGICAL MAGAZINE (p. 507), was received from a dealer, labelled *Rhinoceros pachygnathus*, Wagn., and determined by me as *Leptodon*, for the reasons stated in my notice.

The skull is represented on Pl. XXIV, Fig. 1, of half natural size, left side view. The right side is damaged, and the anterior extremity, as seen from the figure, is wanting. The outline of the posterior part is misleading, as it seems to represent the contour of the occiput; this is due to the objectionable practice of shaping the matrix where the bone is absent, so as to make the specimen appear more perfect; the fossil was received in this state. What appears as the postero-inferior angle of the skull is the post-glenoid process. On the upper side of the skull the posterior part of the frontals and the upper parts of the parietals are missing, but the matrix beneath is preserved almost intact, so as to compensate partly for the missing bone. Temporal crests are thus seen to have been present, and these, starting from the posterior margin of the orbits, and converging backward, unite to form a sagittal crest, at a point situated approximately above the anterior border of the glenoid articulation.

The orbits are comparatively small, closed behind, situated high up and far backward (above m. 3).

The zygomata are very high throughout, short and strongly arched; their shortness backward from the orbit is of course in relation with the latter's posterior position.

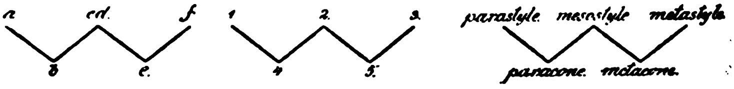
The infraorbital foramina are situated far backward, their posterior margin corresponding to the anterior part of m. 1. The bony palate is prolonged posteriorly beyond the molar series, so that the anterior border of the *choanæ* is situated about 25 mm. behind a line uniting the posterior ends of the two m. 3.

The true molars, which are considerably worn, present the following characteristic features:—

First of all the great elongation of m. 3, due to an additional third lobe, a sort of posterior heel. A common feature of the three true molars is the strong development of the outer cusps, numbered 1 and 2. The molars also appear to be less lophodont than we shall find to be the case in recent Hyracidæ; although much worn, they show traces of two cusps on the inner side. The conformation of the external parts of m. 1 and m. 2, showing only two protuberances or cusps, separated by a fold, is at first somewhat puzzling, and necessitates my entering into some further particulars. The outer part of upper molars of Ungulata being represented by a greater number of cusps, the question is, which cusps are missing in these much worn molars.

So far back as 1873 I described the outer parts of upper molars as being composed of six cusps, which in my figures were designated by the letters *a*, *b*, *c*, *d*, *e*, *f*, proceeding from before backward, and I added that all the differences were to be traced back to the respective position of these six parts to each other and to their relative development.[1] When criticizing these views, Schlosser maintained that *a*, *c*, *d*, and *f* are not essential parts of the tooth, but mere secondarily developed crests or tubercles.[2] However, as Winge had shown in the meantime, in such low mammals as Insectivora and Polyprotodont Marsupialia, these cusps are arranged in two longitudinal series, much more independent of each other than in higher Mammalia. He admits five cusps, and numbers them from before backward 1, 2, 3, 4, 5; cusp 2 corresponding to my *c*, *d*. The first three (1, 2, 3) form the outer, the latter two (4, 5) the inner series, and he further states that the former are the original three cusps of the Mammalian molar, the homologues of the three cusps of Triconodonts.[3] At any rate they are remarkably developed in several upper Cretaceous Mammalia from the Laramie.[4] According to the nomenclature of Osborn, who in his turn considers the outer cusps (-styles) as secondary formations, the five cusps are, always proceeding from before backward, the parastyle, paracone, mesostyle, metacone, metastyle, or, considering their arrangement in two longitudinal series: parastyle, mesostyle, metastyle (outer series); paracone, metacone (inner series).

In Ungulates these different parts are connected together, so that the tooth presents a W-shaped outer wall, usually shallow.


F. M. (1873). Winge (1882). Osborn.

The more a tooth is hypselodont, the more its outer wall becomes flattened, and the folds dividing the cusps tend to disappear; as may be seen by comparing my figures of brachyodont (Figs. 4, 5) with those of hypselodont (Fig. 3) Hyraces, in which I have adopted Winge's mode of numbering the cusps. In the brachyodont teeth 1 and 2 are very prominent, and in both brachyodont and hypselodont Hyraces the fold dividing 2 and 5 is particularly shallow, and tends to disappear in the course of wear, at an earlier date in hypselodont, very late in brachyodont Hyraces; so that very often 2 and 5 become fused together, as is the case in m. 1 of Fig. 3 (in the figure this fusion is not so apparent as in the original). The final result is that in worn molars the fold between 4 and 2 seems to divide the outer wall of the tooth in two equal halves; but the less worn teeth show that in reality the part of the outer wall anterior to the fold mentioned is composed of two cusps, 4 and 1, the part posterior to it, of three cusps, 2, 5, and 3.

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[1] Palæontographica, vol. xxii (1873), p. 101, pl. vi.

[2] Morphol. Jahrb., xii (1887), p. 102.

[3] Vidensk. Meddel. Naturh. Foren. Kjöbenhavn, 1882, p. 15, pl. iii.

[4] H. F. Osborn, "Fossil Mammals of the Upper Cretaceous Beds": Amer. Mus. Nat. Hist. and Art, vol. xvii (1893), pl. viii.

The foregoing statement already partly disposes of the alleged close agreement between upper teeth of hypselodont Hyraces and those of Rhinoceridæ, which has been repeatedly maintained; it has even been said that the former have "the same pattern as those of *Rhinoceros*." The Rhinoceridæ (and Hyracodontidæ) were characterized by Cope as having the "anterior exterior crescent of superior molars more reduced."[1] Osborn has more precisely defined this character of Rhinoceridæ by stating that "the character separating the Rhinoceroses from all other lophodonts is the asymmetry of the external cusps, the metacone being longer than the paracone"; and he adds besides that the anterior lobe arises from the apex of the paracone, just as the posterior lobe arises from near the apex of the metacone.[2]

A notable difference between the upper molars of Hyracidæ and Rhinoceridæ is the absence of cusp 2 (mesostyle), and the fusion of cusp 3 with the metacone in the latter,[3] which accounts for the "elongation of the metacone," and the asymmetry of the remaining external cusps. This asymmetry is due besides to the circumstance, that cusp 4 (paracone) projects more outwards than 5, whereas even in those Hyracidæ in which 2 becomes fused with 5, no asymmetry is the result.

I find that the teeth of both hypselodont and brachyodont Hyraces have the same pattern; the only difference being, as already mentioned, that the outer wall of the former has all the cusps and the intervening folds so reduced that its contour, instead of having the shape of a shallow W, as in the brachyodont teeth, represents a slightly undulated longitudinal line. Besides, there are species of Hyracidæ which are semi-hypselodont, being neither brachyodont nor hypselodont.[4]

As regards the transverse crests or lobes in the upper teeth of Hyracidæ, unworn teeth, whether brachyodont or hypselodont, show each of the two crests incompletely divided into two cusps, the outer smaller ones being apparently the intermediate conules; these very soon become fused with the inner cusps so as to form the crests. In unworn teeth the inner cusps almost touch the outer wall (Fig. 4), and at an early stage of wear (Fig. 5) they become fused with the inner part of cusps 4 and 5 respectively, while the intermediate conules, the outer cusps of the crests, tend respectively towards cusps 1 and 2 of the outer wall (Fig. 4) and become ultimately, in their turn, fused with them (Figs. 5 and 3).

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[1] Bull. U.S. Geol. Geogr. Surv., vol. v (1879), p. 228; Am. Natur., vol. xiii (1879), p. 771*a*.

[2] H. F. Osborn, "The Extinct Rhinoceroses": Mem. Amer. Nat. Hist., ser. I, vol. iii (1898), pp. 87, 88.

[3] There is a trace of it in some of the Oligocene Rhinoceroses, as shown in Osborn's figures of *Aceratherium occidentale* and *A. tridactylum*, op. cit., p. 109.

[4] Other characters also, which, like those referred to, have been made use of for dividing the Hyracidæ into two or three genera, prove not to be constant. Thus, a very competent writer, who, as a rule, at least of recent years, is not particularly coy when it comes to the splitting of genera or species, has "come to the conclusion that it is better on the whole to recognize only a single genus for the whole of the Hyraces." (O. Thomas, "On the Species of the Hyracoidea": P.Z.S. London, 1892, p. 52.)

When comparing our figures of the Hyrax teeth with the diagram of a *Rhinoceros*-tooth[1] it becomes apparent that in the latter each crest unites with the outer wall in one place only, and this fusion is as a rule brought about by those parts of the crests which correspond to the intermediate conules.[2]

The upper cheek teeth of Hyraces exhibit besides an anterior and a posterior basal cingulum, and, less frequently, an outer one also. All these secondary parts, including the last one, are represented in the molars of *Pliohyrax* (Fig. 2). The main differences between the fossil and the recent teeth, apart from the complication of the fossil m. 3, are the following: (1) The fossil teeth are more bunodont; for, as far as their worn condition permits us to judge, the inner cusps remained independent for a longer time than in recent Hyraces (compare Fig. 2 with Fig. 3). (2) In the fossil teeth the outer cusps (1 and 2), especially the latter, Osborn's mesostyle, are more prominent than in Hyraces. Both these characters point towards a more primitive condition of the fossil teeth.

MEASUREMENTS.

	mm.
Length of the three true molars in the middle line	94
Breadth of skull from sagittal suture to outer margin of orbit (the greatest breadth of the skull would therefore be approximately 210 mm.) ...	105
Breadth of skull between posterior external margins of the infraorbital foramina	90·5
Breadth of palate between anterior parts of m. 1	45
Maximum of vertical height of orbit	43
Long axis of same	46
Height of zygoma below orbit	48
From posterior upper margins of infraorbital foramen to anterior margin of orbit	69

The addition to our knowledge of the genus '*Leptodon*,' due to the skull in the British Museum, does not bring us nearer to the Hyracidæ than the mandible described by Gaudry; for, besides some differences pointed out in the molars, the recent Hyraces differ in their skull from the fossil—(1) by comparatively larger orbits, situated at a lower level, and not so far backward as in the latter; (2) by the anterior border of the orbits being situated either above the anterior margin of the posterior premolar (p. 1), or, in the species with smaller cheek teeth, even above the anterior part of p. 2; (3) by the more anterior position of the infraorbital foramina;

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[1] Osborn, op. cit., p. 87, fig. 5.

[2] It seems probable that what is called 'crochet' in the *Rhinoceros*-tooth is the homologue of the posterior intermediate cusp (metaconule); therefore, in those teeth in which the crochet is present as such, the inner cusp of the posterior lobe (hypocone) would appear to join directly the outer wall.

(4) by the bony palate not being prolonged backward beyond the molar series.

A characteristic feature of the Hyraces is revealed by a second skull from Samos, which found its way to the Stuttgart Museum, and has been described and figured by Osborn.[1] "The relationship of *Pliohyrax* to *Hyrax* is . . . . obvious in the enlarged pair of incisor teeth and in the lophoselenodont structure of the molar teeth, which characters respectively determine its subordinal and ordinal position."

In the side view of the Stuttgart skull,[2] drawn from a photograph, the infraorbital foramen appears to occupy the same position as in the cranium of the specimen in the British Museum. In the portion situated behind the foramen, I am quite unable to distinguish between what is bone, what is matrix, and what may be artificial sculpturing of the latter. The only reference to this part in the text is the statement on p. 172, of "the elevated position of the orbits," wherein we have a further agreement with the British Museum skull. A third point in which the Stuttgart fossil agrees with that of London is "the extreme backward extension of the posterior nares."

The antemolars cannot be compared, the only premolar preserved in the British Museum skull (p. 1) being considerably damaged and, besides, out of position (the inner side is turned outwards). However, its molariform pattern and the presence of cusp 2 (mesostyle), as described by Osborn in p. 1 from Stuttgart, are clearly discernible. Of p. 1 and p. 2 the same writer says, that they "present an inward and backward cingular extension of the protoloph which may be a specific character." The same may be seen in much worn premolars (and molars) of recent Hyraces, the explanation being that the cingulum cusp at the opening of the great inner fold becomes fused with the anterior lobe.

Owing to the bad preservation of the true molars in the Stuttgart cranium little information could be gathered from them, but this agrees also with the specimen in the British Museum. "The molars increase in size posteriorly, and are extended well back behind the junction of the zygomatic arch with the face. . . . In the first superior molar . . . a prominent mesostyle is seen separating the external lobes, and these are of the lophoselenodont type of *Palæotherium* and *Hyrax*."[3]

Osborn is of opinion that *Pliohyrax* may possibly be the representative of a new family of the Hyracoidea, a view which is rather corroborated than not by the additional information obtained from the British Museum skull.

The collection from Samos in the Munich Palæontological Museum has yielded to Schlosser[1] an almost complete lower jaw, which he identifies as being of the same species with the skull in the Stuttgart Museum, and he even believes that both may belong to the same specimen. While referring the reader to Schlosser's description of the conformation of the lower premolars, canine, and incisors, and to Osborn's figure (pl. ii, fig. 3) of the upper ante-molars, I wish to recall the fact that from the conformation of the anterior lower premolar of his *Leptodon græcus*, Gaudry had already rightly concluded that the lower canine "a dû être en contact avec la première prémolaire et avoir une faible dimension."[2] This conclusion has been fully borne out by Schlosser's discovery of the Samos mandible.

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[1] H. F. Osborn, "On *Pliohyrax Kruppii*, Osborn, a fossil Hyracoid, from Samos, Lower Pliocene, in the Stuttgart Collection. A new type, and the first known Tertiary Hyracoid": Proc. Fourth Internat. Cong. Zoology, Cambridge, 22–27 August, 1898; pp. 172, 173, pl. ii (1899).

[2] Op. cit., pl. ii, fig. 1.

[3] Op. cit., p. 173.

From what has been ascertained by these successive discoveries, it is now satisfactorily established—(1) That the four fossils in Paris, Stuttgart, Munich, and London belong to a single genus; the name *Leptodon* being preoccupied, as was pointed out to me by Mr. Lydekker, it will have to be known as *Pliohyrax*. (2) That the mandible from Pikermi in the Paris Museum and the skull from Samos in the British Museum are, moreover, the same species, *Pliohyrax græcus* (Gaudry). (3) The mandible at Munich and the skull at Stuttgart, both from Samos, have been shown by Schlosser to be the same species.

Whether all four fossils are one and the same species, may be decided when exact measurements of the Stuttgart skull are available. M. 1 of the London and the same tooth of the Stuttgart specimen are approximately of the same size; but the skull of the latter seems to be somewhat smaller. This may be due either to individual or to sexual variation; I have in my first note pointed out, that the shape of the large incisors in the Stuttgart fossil exhibits a greater agreement with the incisors of female Hyraces than with those of male specimens.

EXPLANATION OF PLATE XXIV.

Fig. 1.—*Pliohyrax græcus* (Gaudry). Brit. Mus., No. M 5,419. Side view of cranium. ½ nat. size.

Fig. 2.—Left upper true molars of same. Nat. size.

Fig. 3.—*Procavia capensis* (Pall.). First and second left upper true molars (m. 1, m. 2). 2 × 1.

Fig. 4.—*Procavia dorsalis* (Fraser). First left upper true molar (m. 1), very slightly worn. 2 × 1.

Fig. 5.—*Procavia dorsalis* (Fraser). First left upper true molar, more worn than in the specimen Fig. 4. 2 × 1.

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[1] M. Schlosser, "Über neue Funde von *Leptodon græcus*, Gaudry, und die systematische Stellung dieses Säugethieres": Zool. Anz., xxii, pp. 378–80, 385–7 (1899).

[2] A. Gaudry, op. cit., p. 215.

V.—NOTE ON *AMMONITES CALCAR*, ZIETEN

By G. C. CRICK, F.G.S., of the British Museum (Natural History).

IN his work[1] entitled "Die Versteinerungen Würtembergs" C. H. v. Zieten figured and briefly described[2] a species under the name *Ammonites calcar*. The description is as follows:—"Rücken gewölbt, Rückenlinie spornradförmig gezackt; er hat in dem Bau seiner Rippen und dem erhöhten Saum seiner Windungen grosse Aehnlichkeit mit dem vorhergehenden [i.e. *Ammonites bipartitus*, Zieten], unterscheidet sich jedoch von ihm sogleich durch seine einfach gezackte Rückenlinie. Aus dem untern Oolith bei Guttenberg."[3]

In the same work he also figured a species, which he named *Ammonites bipartitus*[4] and characterized in the following terms:—"Rücken flach, Sipho darauf sehr wenig vorstehend, zwischen zwei Reihen schräg gegen einander überstehender Zähne; die innern Windungen von den äusseren stark bedeckt, deren Mitte auf der Seite durch einen erhöhten Saum getheilt scheint, an dessen inneren Seite sich die Rippen einfach in spitzigen Winkeln anlegen, von seiner äusseren Seite dagegen doppelt bis zu den Zähnen seines Randes hinlaufen. Aus dem untern Oolith unweit Guttenberg."

In the British Museum (Natural History) collection [Register No. 37,670] there is an example (see Fig. 1) of Zieten's *Ammonites calcar*, which bears a label to the following effect in the handwriting of Dr. Bruckmann, from whom the specimen was obtained:—"*Ammonites calcar*, Benz.,Zieten. Ausserst selten. Ist nach Quenstedt ein kranker *bipartitus*. Brauner Jura ζ, Gamelshausen." On the label there has been written in pencil, in the same handwriting, the letters "[Dr. O.]," signifying Dr. Oppel, as I have been able to ascertain from the labels accompanying other specimens in the

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[1] This work was issued between 1830 and 1834 in twelve parts of six plates each, as follows:—

Heft	i, 1830,	pp.	1–8,	pls.	i–vi,	*fide* Neues Jahrbuch,	1830, p. 404.
,,	ii, 1830,	,,	9–16,	,,	vii–xii,	,, ,,	1831, p. 336.
,,	iii, 1831,	,,	17–24,	,,	xiii–xviii	,, ,,	1832, p. 118.
,,	iv, 1831,	,,	25–32,	,,	xix–xxiv		
,,	v, 1832,	,,	33–40,	,,	xxv–xxx	,, ,,	1833, p. 111.
,,	vi, 1832,	,,	41–48,	,,	xxxi–xxxvi		
,,	vii, 1832,	,,	49–56,	,,	xxxvii–xlii	,, ,,	1833, p. 244.
,,	viii, 1832,	,,	57–64,	,,	xliii–xlviii		
,,	ix, 1833,	,,	65–72,	,,	xlix–liv	,, ,,	1833, p. 624.
,,	x, 1833,	,,	78–80,	,,	lv–lx		
,,	xi, 1833,	,,	81–88,	,,	lxi–lxvi	,, ,,	1834, p. 245.
,,	xii, 1833	,,	89–96 Alphabetical Register, pp. 97–102	pls.	lxvii–lxxii		

[2] Heft iii, 1831, p. 18, pl. xiii, figs. 7*a*, *b*, *c*.

[3] Zieten attributes the species to 'Benz.,' but gives no reference to that author. Probably, therefore, Zieten was the first to publish a description of the species, and must be regarded as its author.

[4] Heft iii, 1831, p. 18, pl. xiii, figs. 6*a*, *b*, *c*.

British Museum (Natural History) that were also obtained from Dr. Bruckmann. The fact that the "species" is very rare and that this specimen has been labelled, "*Am. calcar*, Zieten (unique)," and marked "Zieten coll.," at once suggested a comparison of the example with Zieten's figure. So exactly did it agree with Zieten's figure that I was led to enquire whether Zieten's type-specimen was known to exist elsewhere.

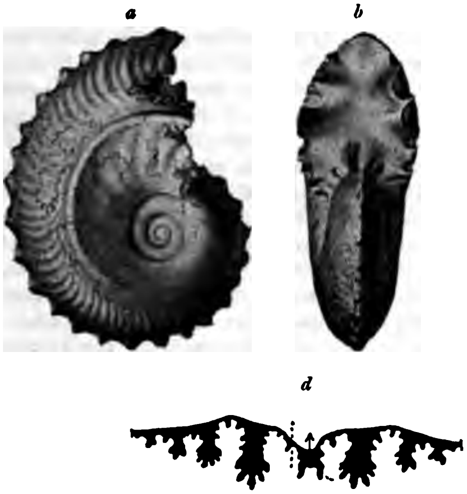

FIG. 1.—Zieten's type-specimen of *Ammonites calcar* [= a deformed example of *Bonarellia bicostata*, Stahl, sp.]. *a*, lateral view; *b*, front view, showing the single row of tubercles on the periphery and the asymmetry of the septal surface; *c*, peripheral view, showing the single row of tubercles near the centre of the periphery; *d*, suture-line, the dotted line near the middle indicating the position of the single row of tubercles, and the short curved lines at each end marking the position of the suture of the shell. Brown Jura ζ (Lower Oxfordian): Gammelshausen, near Boll, Württemberg. Drawn of about twice the natural size, from the specimen in the British Museum (Natural History) collection [37,670].

In one of his papers on "The Fossil Cephalopods of the Museum of Comparative Zoology,"[1] at Harvard College, Cambridge, Mass., Professor Hyatt refers to "specimens from Zieten's former collection," which were sent to that Museum by the Museum of Stuttgart.

Replying to my enquiries, Dr. E. Fraas, of Stuttgart, very kindly informs me that there are only a few of Zieten's type-specimens at Stuttgart, that the type-specimen of *Ammonites calcar* is not among them, and that the large collection there does not contain a single specimen that can be referred to that 'species.' He also states that he does not consider *Ammonites calcar* to be a distinct species, but a deformed example of some other species, possibly of *Ammonites bipartitus*.

Professor Koken, of Tübingen, tells me that, with few exceptions,

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[1] Bull. Mus. Comp. Zool., vol. i (1864–9), p. 79.

Zieten's originals are not in Tübingen, but that the collection there contains the two examples of *Ammonites calcar* figured by Quenstedt. According to Zieten's own statement on the title-page, the originals of his "Versteinerungen Würtembergs" were in the collection of Dr. Hartmann, in Göppingen, after whose death they passed, according to Professor Koken, into the hands of Krantz, of Bonn. In all probability, therefore, the specimens were dispersed, and we think there can be no doubt whatever that the example now in the British Museum collection is Zieten's type-specimen.[1] It must, however, be pointed out that this example is labelled in Dr. Bruckmann's handwriting, "Brauner Jura ζ, Gamelshausen," whereas Zieten states that this species came "aus dem untern Oolith bei Guttenberg."[2]

A minute examination of the British Museum specimen—subsequently referred to as Zieten's type-specimen—shows it to be deformed. Firstly, the two branches of the siphonal lobe, instead of being placed one on each side of the median line of the periphery, are both on the left[3] side of the median row of tubercles, so that the septum, when viewed from the front (see Fig. 1*b*), is decidedly unsymmetrical. Secondly, a close examination of the tubercles on the periphery, especially of those near the anterior end of the specimen, reveals an indication of subdivision in the median line, as if each were formed by the coalescence of two antero-posteriorly elongated tubercles. Further, the whole specimen is not quite symmetrical, the left side of the whorl being a little more inflated than the right, and the peripheral tubercles a little on one side of the median line (see Fig. 1*c*).

Quenstedt[4] regarded Zieten's *Ammonites calcar* as a deformed example of *Ammonites bipartitus*, Zieten, and in this opinion was supported by Bronn[5] and Oppel,[6] for both these authors referred *Amm. calcar* and *Amm. bipartitus* to the same species (*Ammonites bicostatus*, Stahl), the last-named author adding in a parenthesis after the reference to *Amm. calcar* the word 'Missbildung.' Giebel,[7] however, regarded *Amm. calcar* as a separate species, an opinion which appears to be shared by Parona and Bonarelli.[8]

On comparing Zieten's figure of *Ammonites calcar* with that of his *Amm. bipartitus* a great similarity in the sculpture is at once apparent, and this, together with Zieten's statement that *Ammonites bipartitus* also came "aus dem untern Oolith unweit Guttenberg," suggests a possible relationship between the two forms. This apparent relationship is confirmed by the comparison of Zieten's type of *Amm. calcar* with a normal example of his *Amm. bipartitus,* of which species there are several German examples [1] in the British Museum collection. Several other differences are apparent besides the arrangement of the tubercles on the periphery. Thus, compared with an example of Zieten's *Amm. bipartitus* of about the same size, *Amm. calcar* has more inflated whorls and a slightly smaller umbilicus. This is clearly shown by a comparison of the dimensions of the specimens. Thus the measurements of Zieten's type-specimen of *Amm. calcar* are:—Diameter of shell (excluding spines), 20·5 mm. (100); width of umbilicus, 4·5 mm. (21·9); height of outer whorl, 10 mm. (48·7); height of outer whorl above preceding whorl, 8 mm. (39·0); thickness of outer whorl, 7·5 mm. (36·5): whilst the dimensions of an example of Zieten's *Amm. bipartitus* from the Brown Jura ζ, Beuren, Württemberg [C. 7,267*b*] at the same diameter are:—diameter of shell (excluding spines), 20·5 mm. (100); width of umbilicus, 5 mm. (24·3); height of outer whorl, 9·5 mm. (46·3); height of outer whorl above preceding whorl, (?); thickness of outer whorl, 7 mm. (34·1): and the dimensions of a smaller but slightly more inflated example [22,324*b*] of the same species are:—diameter of shell, 19·5 mm. (100); width of umbilicus, 4·5 mm. (23·0); height of outer whorl, 9 mm. (46·1); height of outer whorl above preceding whorl, 7 mm. (35·8).

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[1] This view is supported by the subsequent discovery in the Museum collection of two more of Zieten's type-specimens (*Ammonites discoides*, p. 21, pl. xvi, figs. 1*a*, *b*, *c*; and *Ammonites polygonius*, p. 21, pl. xv, figs. 6*a*, *b*, *c*), both of which were obtained from Dr. Bruckmann.

[2] The only place of this name in Württemberg that the writer has been able to find is about eight miles due east of Dettingen and is spelt 'Gutenberg.' Gammelshausen is near Boll, which is about nine miles north-east of Gutenberg. There is also a discrepancy about the horizon and locality of the two other specimens in the Museum collection that are believed to be Zieten's types.

[3] The terms 'right' and 'left' are used in a purely morphological sense.

[4] F. A. Quenstedt: "Petref. Deutsch.," Bd. i, Cephalopoden (1846), p. 140; and "Amm. Schwäb Jura," Bd. ii (1887), p. 736.

[5] H. G. Bronn: Index palæont., 1848, p. 33.

[6] A. Oppel: "Die Juraformation," 1856–58, p. 560 (1857).

[7] C. G. Giebel: "Die Fauna der Vorwelt," 1852, p. 567.

[8] C. F. Parona & G. Bonarelli: Mém. Acad. Sci. Savoie, sér. 4, vol. vi, p. 141, 1897.

Compared with that of *Amm. bipartitus*, the suture-line of *Amm. calcar,* besides being unsymmetrical, presents slight differences in its details (compare Figs. 1*d* and 2), but all these may, we think, be attributed to the general deformation of the specimen. As might be expected the greatest difference is in the peripheral portion of the line; the peripheral saddle on each side, especially that on the right in Fig. 1*d*, is much reduced in width, but it, nevertheless, exhibits a subdivision which is clearly comparable with that of the corresponding saddle in *Amm. bipartitus.*

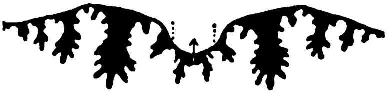

FIG. 2.—*Bonarellia bicostata*, Stahl, sp. Suture-line of normal example for comparison with Fig. 1*d*, the dotted lines near the middle of the figure indicating the position of the row of tubercles on each margin of the periphery, and the short curved lines at each end marking the position of the suture of the shell. Brown Jura ζ (Lower Oxfordian): Balingen, Württemberg. Drawn of twice the natural size from an example in the British Museum (Natural History) collection [39,926].

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[1] There are four examples (22,324*a*–*d*) from the Brown Jura ζ, Beuren, Württemberg; one (39,026) from Balingen, Württemberg; and four others (C. 7,267*a*-*d*) from Germany, but the precise locality of these is not recorded.

On the whole we think there cannot be any doubt that Zieten's *Amm. calcar* is only an example of his *Amm. bipartitus*, deformed in such a manner that the marginal tubercles of the periphery have coalesced into a single row of tubercles occupying nearly the median line of the periphery, just as in the example of *Hoplites tuberculatus* from the Gault of Folkestone, described by the present writer in a previous number (December, 1898) of this Magazine. There are individual differences in *Amm. bipartitus*, among which may be noticed a variation in the prominence of the ridge on the middle of the lateral area, in the number of the marginal tubercles, and in the coarseness of the ornaments. *Amm. calcar* agrees with an average specimen.

Having decided that the type-specimen of Zieten's *Amm. calcar* is a deformed example of his *Amm. bipartitus*, a few words must be added respecting the name of the fossil.

Firstly, in regard to the trivial name. Both Bronn[1] and Oppel[2] considered Zieten's *Amm. bipartitus* to be a synonym of Stahl's *Amm. bicostatus*,[3] and we think there can be no doubt as to the correctness of this identification. Quenstedt[4] refers Zieten's *Amm. bipartitus* and Stahl's *Amm. bicostatus* to the same species, for which, however, he adopts the name *Ammonites bipartitus*. But since Stahl's name antedates Zieten's by some seven years it should stand, and the trivial name of the fossil should be *bicostatus*.

Secondly, in regard to the generic name. There is no difficulty about the generic name of this species, for Munier-Chalmas[5] selected *Ammonites bipartitus*, Zieten, as the type of a new genus, for which he proposed, in 1892, the name *Distichoceras*, without, however, giving any diagnosis of the genus. This was subsequently supplied by Parona & Bonarelli,[6] who gave not only a diagnosis of the genus, but also a list of the forms which they included in it. Cossmann,[7] however, points out that this name is preoccupied by *Distichocera*, of Kirby, and accordingly alters it to *Bonarellia*.

Hence the British Museum example of Zieten's *Ammonites calcar*, which is most probably the type-specimen, is merely a deformed example of *Bonarellia bicostata*, Stahl, sp.

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[1] H. G. Bronn: Index palæont., 1848, p. 33.

[2] A. Oppel: "Die Juraformation," 1856–58, p. 560 (1857).

[3] G. Stahl: Corresp.-Blatt Würt. Landwirthsch. Ver., Bd. vi (1824), p. 49, fig. 9. Stahl's description is as follows:—"Er hat eine vertiefte Rückenlinie, deren Seiten nach aussen mit kleinen Zühnen besitzt sind; von jedem Zahn gehen zwei Streifen bis an die in der Mitte der Windungen hinlaufende Streifungslinie, von wo an die andere Hälfte der Windung glatt ist. Er findet sich verkiest bei Gammelshausen im jungern bituminösen Mergelschiefer; erfordert übrigens noch nähere Untersuchung."

[4] F. A. Quenstedt: Amm. Schwäb. Jura, Bd. ii (1887), p. 732.

[5] Munier-Chalmas: Bull. Soc. Géol. France, ser. 3, vol. xx, No. 6, Comp. rend., p. clxxi, 1892.

[6] C. F. Parona & G. Bonarelli: Mém. Acad. Sci. Savoie, sér. 4, vol. vi, p. 139, 1897.

[7] M. Cossmann: Rev. crit. de Paléozool., vol. ii, p. 75, 1898.

VI.—MR. HUDLESTON "ON THE EASTERN MARGIN OF THE NORTH ATLANTIC BASIN."[1]

By Prof. J. W. SPENCER, M.A., Ph.D., B.A.Sc., F.G.S.

THE delay of several months, in replying to Mr. Hudleston's communication relative to the above-named subject, has been due to absence in the field in a distant region, where I was not in touch with the current literature.

In the study of suboceanic topography, it is to be regretted that most of the writers use the hydrographic unit of measure — the fathom—where the investigations have for their object the comparison of the submarine features with those of the land where the unit is in feet. This use of two units dims the comprehension, unless the differential measurements are translated into the same standard.

On nautical charts, the 10- and 100-fathom contours are generally drawn for navigation purposes, and the latter is the only contour-line that usually approaches the suboceanic continental margins. Hence this line is most commonly spoken of as if identical with the submerged margin of the continent. This inaccuracy would scarcely obtain were the measurements in feet adopted. The edges of the submarine platforms vary all the way from 300 to 1,200 feet, though the margins of the outer shelves often reach to 3,000 feet or more.

In the study of the peculiarities of the suboceanic continental margins, contours of 1,000 or 500 fathoms apart are not sufficiently close to bring out the features in an intelligent way, although they may be all that are practicable on a map of small scale. By drawing them at 200 or 300 feet apart, I have found that many difficult features became easily explicable. If Mr. Hudleston had taken the fullest data and contoured the slopes from 100 to 1,000 fathoms on his map of the "British Biscayan Atlantic," with isobars of 200 or 300 feet, it is possible that he would not have found that the soundings "in certain localities round the Bay of Biscay are curious and perplexing." It is such curious and perplexing features as these, made known to a better degree in more favoured regions, which I have studied in large numbers, and which Professor Hull has found and more fully studied off the European coast. But Mr. Hudleston, in his really valuable paper, does not seem to have recognized their importance.

The first striking feature in Mr. Hudleston's paper is his study of the gradients of the suboceanic continental slopes. He has shown a very large number of cases where the declivities at different points amount to from only 1 in 188 to 1 in 7 or 8, except in the Bay of Biscay, where they may be as much as 1 in 4 or 5, and in one case so precipitous as to reach a deepening of one foot in two. His averages are those extending usually over considerable distances of 20 miles or more. The conclusion drawn from them is that the great continental slopes are not vertical or nearly vertical precipices, which neither Professor Hull nor I ever stated, and, therefore, much of Mr. Hudleston's labour for the apparent purpose of refutation is lost. But on analyzing his method, it is found superficial only, as it does not give us a true idea of the variable forms and pitch of the continental slope. In other regions, notably the Floridian channel, leading to the Gulf of Mexico, the analyses of the soundings show that the mean slope in no way conveys an impression of the actual form of the deepening of the channel. The floor of the submerged valley is in reality made up of a series of very gentle gradients, or almost horizontal steps, separated by precipitous declivities. The margin of the Mexican plateau—back of Vera Cruz—has an elevation of somewhat more than 8,000 feet above the sea, or 6,500 feet above the inner margin of the coastal plain. Following up one indentation, the average declivity is only 1 in 30, while at another point it is 1 in 10. But these averages do not suggest the declivity of the great escarpment, for the slope is made up of a series of steep gradients, often 1 in 3 or 4, or perhaps in places 1 in 2, separated by zones of comparatively small pitch. The soundings along the Atlantic margin, which Mr. Hudleston has studied, may not have been close enough to reveal the steps, although he has shown that in the Bay of Biscay the declivities are precipitous. It appears to me that his citations of the mean declivity of the continental slope scarcely become a criticism of the characteristics of the great drowned valleys, as pointed out by Professor Hull and myself.

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[1] GEOL. MAG., Dec. IV, Vol. VI (1899), pp. 97–105 and 145–157.

A second feature made by his studies of the suboceanic continental slope is that it is continuous over great distances (which is perfectly correct), and that the Norwegian basin is an extension of that of the North Atlantic; or, as expressed by him, "it is obvious from an inspection of the accompanying map that the eastern part of the North Atlantic, the Norwegian Atlantic, and a portion of the North Polar ocean, all belong to one and the same great geosynclinal depression, which has been partly interrupted by volcanic extravasation, more especially in the region between Shetland and south-east Greenland." This view cannot pass unchallenged. The ("eruptive") barrier extends *practically* from Europe to Greenland; and between points where the depth of even the valley-like extensions of the basins is 12,000 feet the breadth of the barrier is 600 miles or more, and it rises to within 2,000 feet of the surface of the ocean. Such a barrier, rising 10,000 feet out of 12,000 feet, is certainly too stupendous to be considered as only a partial interruption in one oceanic basin. As a matter of fact there are two basins (and the more northern is apparently continuous with that of the great Polar Sea), just as the Caribbean and Mediterranean basins are distinct from that of the Atlantic. If we could regard this Icelandic plateau in the manner that Mr. Hudleston does, as a volcanic extravasation, interrupting the continuity of the Atlantic basin, it might obviate the necessity of explaining the valley-like features of the ridge. He further says: "to the westward, beyond the centre of Lightning channel ('which is that eastward of Faroe

Islands') all the known land and presumably most of the submerged land is of igneous origin." This last conclusion, applied to a barrier nearly a thousand miles long and hundreds of miles in width, seems to me a more extravagant conclusion than the amount of changes of level postulated by Professor Hull and myself. The central American barrier, between the Caribbean Sea and the Pacific Ocean, is of even smaller proportion, and those parts of it which are above water show a prevalence of volcanic rocks of comparatively recent date; yet from beneath these rocks old crystallines are occasionally exposed, and remains of the earlier Tertiary formations are widely distributed. So, too, it is hardly justifiable to suppose that there is no diversity of formations on the Icelandic plateau, which would suggest continental features; accordingly, the student of submarine topography is forced to analyze the land-like forms of the ridge, all the more so as the valleys and their tributaries, cirques, and embayments suggest that they were fashioned in the same manner as other submarine and subaërial valleys, far away from great plateau eruptions.

A third feature noticeable in the paper is a general overlooking of the detailed form of the edge of the platform, where the soundings "are very irregular and puzzling, so much so that it is not easy to deduce any mean angle of inclination." There is no special reason why a *mean* slope should be found. It is the study of such "curious and perplexing" features which has given rise to the bold hypothesis of tremendous changes of level of land and sea. Therefore, so long as Mr. Hudleston overlooks the amphitheatres and valley-like indentations of thousands of feet in depth, dissecting the continental margins, he has not the facts before him to warrant the *ex cathedra* conclusion—that stupendous changes of level have not occurred.

However, Mr. Hudleston has spoken of the Norwegian channel from the Skager Rack, which has long been known and written upon. Its breadth seems to be greater than he is prepared to accept as that of a valley, although it is a strong feature from Christiania Fjord, rounding the point of Norway, and extending 500 miles to the oceanic abyss. Its breadth should be no difficulty, for it is not as great as that of the lower St. Lawrence merging into the Gulf of the same name; and the flood plains of the land-valley of the lower 500 miles of the Mississippi are from 30 to 80 miles wide, with its lower portion now buried by sediments to a depth of 1,000 feet. This Norwegian channel has a depth, near its head, of 2,658 feet, but farther seaward, as it is crossing the subcoastal plain, its depth is reduced to 960 feet, unless the soundings do not reveal the deepest portions of the channel. He considers this feature "unfortunate" for the theory of its being the course which drained the Baltic valley, and says: "the river of the Baltic, therefore, must have had some difficulty draining towards the Atlantic under these circumstances." Professor Hull and Professor Bonney have answered these points. As shown by them, it is in a region of glacial distribution; so that an easy explanation is seen in the unequal filling of the old valley, such as is known to have frequently occurred. As an illustration of such obstruction, the ancient Laurentian valley between Georgian Bay (eastern portion of Lake Huron) and Lake Ontario is entirely obliterated, not merely by being filled with drift, but also by high transverse ridges. These Pleistocene accumulations have a depth of 500 to 1,000 feet. Yet the portions of this ancient valley, beyond both sides of the drift filling, are still open channels beneath the waters of the lakes. Again, the differential elevation may in part have raised the barrier across the Norwegian channel. Such a result has been the case in mostly closing the outlet of the basin of Lake Ontario, which is 738 feet deep; this differential elevation being recorded in the tilting of the beaches adjacent to the lake, but now raised far above it. As the development of this submerged channel is a feature very much greater than its partial obstruction, the hypothesis of its subaërial origin has in no wise been overthrown by Mr. Hudleston's superficially-formed conclusion, touched with sarcasm: a conclusion based upon one feature, namely, obstruction, which is much easier of explanation than the occurrence of the submerged Norwegian valley itself, if it were not of subaërial origin. Accordingly, the grand old valley is not yet placed without the pale of the laws of uniformity, which prevail in both subaërial and submarine valleys.

My conception of the proper treatment of the 'irregularities' in the continental margin, beneath the waters of the Bay of Biscay, differs greatly from that of Mr. Hudleston. For instance, at a point 100 miles south-east of La Chapelle bank, his statement is:—"For at one spot 600 fathoms is marked just outside the 100-fathom line; while at another, further out to sea, a distance of about seven miles, separate soundings of 880 fathoms and 2,100 fathoms respectively, thus giving a slope of 1 in 5, or 11°. In the latter case, the irregularity is not connected with the edge of the 100-fathom platform, but may be said to belong to abyssal depths." His explanation bears only upon the question of the irregularity of the slopes, and does not convey to me any impression that he was making any study of the cirque-like indentation. I should describe the phenomenon as shown upon his own map as follows:—There is a sounding of 3,600 feet (600 fathoms), located a few miles within the line connecting the 600-foot depths on either side, suggesting a cirque in the great continental slope. The trend of this slope on the eastern side of the cirque (or, more correctly speaking, amphitheatre) appears to turn so as to form an embayment due south of the 3,600-foot point, reaching to a depth of 6,420 feet, with a promontory to the east of it rising 860 feet above its floor at this point; thus showing a great amphitheatre-like valley continuing outward from the 600-foot platform. Beyond this point the 12,000-foot contour also shows a marked indentation, corresponding to a continuation of this valley, noted at depths of 3,600 feet and 6,420 feet, although Mr. Hudleston forms a contrary conclusion. At the head of the amphitheatre, there appears to be a precipitous declivity of about 3,000 feet, but from the foot of this declivity the mean gradient of the valley is about

1 in 30; while if I went farther and compared the gradient of the floor of the indentation with the pitch from the promontory upon its eastern side, I should find it 1 in 5 as given by Mr. Hudleston. He has studied only the angle of descent of the continental slopes: I have studied the sculpturing of the slopes, with their valleys and gradients.

This amphitheatre-like indentation, by itself, would not be a strong point, as the data are scanty; but when the feature is one of constant recurrence, and fuller information concerning such features is often obtainable elsewhere, as Professor Hull has shown to be the case at numerous points off the coast of France, Spain, and Portugal, experience makes easy the interpretation of the fragments of drowned valleys which have been recovered.

Turning now to the Fosse de Cap Breton, at the angle of France and Spain, the data are very much fuller, and Mr. Hudleston's treatment is happier, but still falls far short of the facts, as shown upon the chart, which he has reproduced, and therefrom my conclusions reach farther, and fully support the investigations of Professor Hull.

The Fosse dissects the submarine platform, limited by the 600-foot contour, which has a breadth of about 30 miles. It has a depth of 1,260 feet near its head. Farther seaward, the next sounding is 180 feet less, as also two other soundings are less, but these are not in the centre of the channel, as illustrated. Only fuller soundings would prove a barrier, but even then an obstruction by river deposits is what might occur. Another chart,[1] which I have seen, gives more conclusive data than the illustration here analyzed. A little farther outward, the depth has increased to 2,694 feet (on the side of the channel), then to 3,660 feet near the centre, and still farther to 3,750 feet. From this section, Mr. Hudleston passes to "35 miles" farther seaward, and finds soundings of 1,500 fathoms in an outer platform submerged to about 900 or 1,000 fathoms. He then ascertains the mean slope of the side (1 in 7, which is about 750 feet per mile). He cites an example, given by Professor Milne, of the submarine cables being buried by the fall of the vertical walls overhanging them. He concludes as follows: "there are several indications that this depth of 1,500 fathoms represents a hole rather than a channel, for the next sounding seaward shows only 1,250 fathoms." But this last sounding is eight or ten miles from the 1,000-fathom line adjacent to the coast, leaving plenty of room for the intervening channel to reach an additional depth of 250 fathoms. Indeed, to the north-west of the 1,500-fathom hole, and landward of it, the lateral depth is 1,370 fathoms. Between this hole and the Fosse de Cap Breton, already established, there is a chain of soundings of 1,170, 1,107 (this is midway between the 1,500-fathom "hole" and the 625-fathom depth of the fosse), and 915 fathoms, between which and the 625-fathom sounding there is one of only 500 fathoms. In the application of these soundings, it must be

[1] "Submarine Gullies," etc., by Henry Benest: Geogr. Journ., October, 1899, p. 405. The soundings on the Admiralty Chart are very numerous.

borne in mind that the locations are not accurate, and that in offshore hydrography, errors of location up to five miles are permissible (though usually much less) even in good work, when the soundings are made at different times. Consequently, the windings of the valleys are only approximately located, and there may even appear interruptions, but their depths at various points are correct. Under all these conditions, I am forced to give value to the intermediate soundings passed over by Mr. Hudleston, and reach only one conclusion, which is Professor Hull's—that the Fosse de Cap Breton is a continuous valley to beyond the depth of 1,500 fathoms, and from the character of the steep sides it appears to partake of the nature of a cañon. From the soundings, the floor of the fosse, as thus extended, seem to be characterized by three steps, separated by long intervals where the slope is reduced to a few feet per mile, while the mean declivity of the intervening steps is 200 feet per mile. If fuller soundings were made, the steps might be found more abrupt, and there might be a larger number revealed. Mr. Hudleston's explanation of the 1,500-fathom sounding as being a "hole rather than a channel"—an expression used similarly elsewhere—would appear to be a refuge from the valley hypothesis, unless it is shown how such are formed, especially when there is a succession of them.[1]

I wish to correct a criticism. He says, "that Professor Spencer, having long studied the Caribbean Sea—perhaps the most unstable region of the earth—appears to have an exaggerated notion as to epeirogenic uplifts on both sides of the Atlantic"; and he further objects to the hypothesis that the Rockall embayment, west of Ireland, has been fashioned by atmospheric agents, and suggests that both it and the Lightning channels, and the deeps of the Norwegian Atlantic were due to tectonic causes. Whatever were the causes of the basin, the claims of Professor Hull and myself are only that the barriers were once land, which were moulded by atmospheric agents, producing the valleys dissecting them.

I fear that my critic's impression of the instability of the Caribbean region is very much magnified. It is now certainly established that the principal changes of level, since the early Tertiary period, over that region—vastly larger than the Norwegian basin—have occurred with remarkable persistency, though varied in magnitude. And these changes have extended to the North American continent, and continued northward to regions considered the most stable. I suspect that the most of these changes are represented in the eastern Atlantic, which the evidence brought out indicates. At no time have I stated that the same individual oscillations extended to both sides of the Atlantic, as the oscillations may not prove to have been absolutely synchronous. They may yet be found to have alternated. The changes may also have been more complete in one region than another.

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[1] For a restoration of this submerged river channel as determined by Prof. Hull, see Geogr. Journ. for March, 1899, with map.

As to the Rockall embayment and Lightning channels, it may be said that only a brief notice was taken of these by me in my preliminary paper,[1] cited by Mr. Hudleston. In a general way I called attention to the deep valley-like depressions dissecting the submarine Icelandic plateau in both directions. These and the Rockall embayment, with their tributary amphitheatre-like valleys, were regarded as only the more advanced forms of atmospheric sculpturing of the margins of an elevated plateau, similar to land features, of which plenty of examples can be given. But the occurrence of the submarine plateau is explained by Mr. Hudleston as an igneous extravasation, while the dissection of the drowned barrier by deep valleys he attributes to tectonic causes. But he does not even compare the adjacent submarine features (as, for instance, the fjords and their tributary amphitheatres) with like forms of the basaltic plateau of the Faroes, dissected into islands by valleys and fjords, with cirques of 2,000 feet in depth. Neither the hypothesis of the general igneous origin of the Icelandic plateau barrier, nor that of the tectonic origin of the valleys, subsidiary to the plateau formation, does he support by evidence, and in substituting his explanations for the hypothesis of subaërial sculpturing of a former land, he brings back upon himself the *onus probandi* of sustaining his theory.

Mr. Hudleston sums up eight conclusions, and these by themselves would have been mostly accepted by Professor Hull and myself. But the details of the paper appear more strongly to have for their object the discrediting of the hypothesis of great changes of level of land and sea. I thank him for the trouble he has undertaken in bringing out so many points, and producing such good illustrations. It has enabled me to point out some of the methods of investigation adopted by Professor Hull and myself, and I trust that it may be of use to other students. But in nothing that he has shown does there appear testimony against the correctness of conclusions by Professor Hull concerning the great changes of level of western Europe in late geological times. The evidence makes me believe with Professor Hull that the submerged plateaux, with gently undulating topography, or rounded and flattened forms, were old land surfaces, largely brought into being by the laws governing the base-level of erosion during the very long Mio-Pliocene period. Some of the broader valley features may have been produced during some portion of the same period, but, generally speaking, our theory is that the deep channels dissecting the drowned plateaux were formed during a subsequent epoch of high continental elevation, or were reopened and enlarged in it. The evidence in America places the great elevation after the time of the establishment of the modern molluscan life, but before the epoch of the accumulation of the glacial deposits: approximately, about the commencement of the Pleistocene Period. Then the older valleys were being enlarged, and the bounding slopes were being dissected by receding cañons and amphitheatres, which

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[1] Read before the Meeting of the British Association, 1897: GEOL. MAG., Dec. IV, Vol. V (1898), pp. 32–38.

were slowly developed into great and deep channels. We may not have sufficiently distinguished all the older from the newer features. As the amount of erosion performed may seem too great for the supposed period of high continental elevation, we are willing to concede that some of the continuations and enlargements of the more restricted channels, or the embayments terminating them, may be older features, even possibly due in part to tectonic causes, whatever such may be; but this is a question beyond the confines of our present investigations. On account of the great slopes being indented by the newer physiographic forms, we point out the evidence of the subsequent stupendous elevation of the land. We may have to concede to the Pleistocene period a really longer duration than has been popularly supposed. The growth of the valleys, under conditions of variable rainfalls on the elevated plateaux, does give rise to such features as we now find dissecting the submarine platforms; and the denudation under conditions of stupendous changes of level would accelerate the excavation of the valley features, or modify them, as described by Professor Hull and myself.

In place of pointing out the remarkable submarine holes and burying the observations in the tomes of some learned society, we have collected the phenomena and bound them together by a working hypothesis based upon the grammar of geomorphy; a new science as yet not generally mastered, with results at first startling, although they only give expression to some of the changes of land and sea, as taught by Lyell. Our imperfect studies have been met by observations from a different standpoint, as if we did not accept them in the common way; consequently, I do not see that any unanswerable objection has yet been raised to our conclusions. Hardly even enough to spur us on to seek for fresh confirmatory facts. Mr. Hudleston would doubtless drift along with us if he would give the subject the attention which it deserves; and already he says that he is not prepared to deny the connection between Europe and Greenland in mid-Tertiary times, though he fails to see any necessity for it. It was in the mid-Tertiary times that we suppose the great undulating features of the Icelandic bridge began to be formed. I take it that further studies must lead him to distinguish between these features and the deep channels with their tributaries, cirques, etc. But until this differential interpretation of the forms is used, the great changes of level of land and sea in late geological times will doubtless appear startling. Whatever agnosticism there may be concerning the correctness of our conclusions, so long as we are met by hypotheses substituting that of subaërial erosion, it falls upon the advocates of such hypotheses to sustain them with facts. While the changes of level of 3,000 feet would perhaps meet with almost general acceptance, we have not been shown any reason why this limitation should be made, when the valley-like features extend to depths of 9,000 or 12,000 feet, as found by both Professor Hull and myself.

NOTICES OF MEMOIRS.

I.—ON A PROPOSED NEW CLASSIFICATION OF THE PLIOCENE DEPOSITS OF THE EAST OF ENGLAND. By F. W. HARMER, F.G.S.[1]

THE term Red Crag, including as it does beds differing considerably in age, is vague, and, when we attempt to correlate the East Anglian deposits with those of other countries, inconvenient; the Scaldisien zone of Belgium, with its southern fauna, for example, representing one part of it, and the Amstelien of Holland, in which northern, and even Arctic, mollusca are common, another. It seems desirable, therefore, while retaining it for general use, to adopt for its various horizons some more definite and distinctive names.

The Upper Crag deposits arrange themselves geographically in horizontal rather than in vertical sequence, assuming always a more recent as well as a more boreal character as we trace them from south to north. They are the littoral accumulations of a sea which was from time to time retreating in a northerly direction.

The classification now proposed, which is based on palæontological evidence, is as follows:—

	OLDER PLIOCENE.	
Lenhamian	Lenham Beds (Zone of *Arca diluvii*)	Diestien Sands. Waenrode?
	NEWER PLIOCENE.	
Gedgravian	Coralline Crag ...	Zone à *Isocardia cor.*
Waltonian	Essex Crag.	
Walton horizon ...	(Zone of *Neptunea contraria*)	Scaldisien.
Oakley horizon ...	,, ,, ,,	Poederlien.
Newbournian ...	Red Crag of Newbourn, Sutton, and Waldringfield	Amstelien.
Butleyan	Red Crag of Butley and Bawdsey (Zone of *Cardium Greenlandicum*)	
Icenian—Lower horizon ...	Norwich Crag, Southern part.	
Upper horizon ...	,, ,, Northern part (Zone of *Astarte borealis*)	
Chillesfordian	(Estuarine) Chillesford Clay and Sands.	
Weybournian ...	Crag of Weybourne and Belaugh (Zone of *Tellina balthica*). Forest-bed (so-called) Series.	

An analysis of the characteristic mollusca of the different divisions respectively of the Crag here suggested shows a gradual diminution of the percentages of extinct and southern forms and a gradual increase in northern and recent species. The difference between the Gedgravian (Coralline Crag) and Waltonian is shown to be less than has been supposed, and the former is here grouped as Newer instead of as Older Pliocene, as hitherto.

The Crag of Oakley, near Harwich, from which the author has recently obtained nearly 300 species of mollusca, belongs to an horizon different to anything previously described, and serves to bridge over the interval between the Crag of Walton-on-the-Naze and the Red Crag of Suffolk. Its fauna closely resembles that of

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[1] Read before Sect. C (Geology), British Association, Dover Meeting, Sept. 1899.

Walton, but contains some boreal and Arctic species unknown from that place, including *Neptunea antiqua* (dextral), *N. carinata*, and *N. despecta*, and represents the period when northern forms were first beginning to establish themselves in the Crag basin. It is approximately and partly equivalent to the Poederlien zone of Belgian geologists.

The Red Crag beds, the fossils of which are, with few exceptions, the drifted and stratified shells of dead mollusca, seem to have been deposited either against the shore or in shallow water in proximity to it, in land-locked bays or inlets. The position which these inlets successively occupied was from time to time shifted towards the north, in consequence of the upheaval of the southern part of the Crag area described by the author in a former paper.[1] These inlets were silted up, one after another, by masses of shelly sand, but as far as the evidence goes the beds composing the different zones do not overlap. The Waltonian deposits are confined to the county of Essex, the Newbournian occupying the district to the north of the river Stour, and the Butleyan beds occurring along a narrow belt extending northwards from Bawdsey at the mouth of the river Deben. The Icenian deposits which are found to the north of Aldeburgh are shown by their molluscan fauna to belong to a period considerably more recent than any part of the Red Crag. They cover an area 45 miles by 20 in extreme breadth, and in one place are nearly 150 feet in thickness, but they are not anywhere known to be underlain by beds of Red Crag age. In the northern part of the Icenian area *Astarte borealis* occurs, and this species seems to mark a slightly more recent horizon of this zone. The Weybournian Crag, containing *Tellina balthica*, is only known to the north of Norwich, and extends from thence to the Cromer coast. The author now believes that these latter beds are distinct from and of older date than the Westleton Shingle of Prestwich.

II.—ON THE ORIGIN OF LATERAL MORAINES AND ROCK TRAINS.[2]

By J. LOMAS, A.R.C.S., F.G.S.

IN dealing with the accumulations of fragmentary materials associated with glaciers it is necessary to distinguish between deposits which are stationary and the débris riding on or moving with the ice.

The latter, reviving a term used by Rendu, will be referred to as 'rock trains,' and the meaning of 'moraines' will be restricted to stationary deposits, either lateral or terminal.

Lateral moraines are not necessary adjuncts to glaciers. Their distribution, which appears capricious, really conforms to a well-defined law. In glaciers with a straight course, they are feebly, if at all, developed, whereas those moving through winding channels have lateral moraines developed in their concave bends. The débris carried by a glacier either in the ice or on the surface gradually works towards the side in such places where motion is retarded and carrying power reduced. In this respect they conform exactly to the action of rivers which deposit material in their inner bends.

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[1] Quart. Journ. Geol. Soc., vol. lii (1896), pp. 773.

[2] Abstract of a paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

Rock trains may appear suddenly in the middle of a glacier or at the junction of two streams. The first are undoubtedly caused by the erosion of subglacial spurs or crags. Those formed at the point of union of two glaciers are usually regarded as being formed by the joining together of two lateral rock trains.

There are cases, however, where rock trains are formed at the junctions of glaciers, and no lateral rock trains fringe the tributary glaciers. In front of the rocky islands or spurs which separate the glaciers at the point of confluence, a hollow is always seen in which a lakelet often exists. This is the counterpart of the hollow on the down-stream side of a river after passing under a bridge supported by piers.

Objects carried by rivers tend to accumulate in this hollow, and may linger there a long time before they join the main current and get carried away.

Thus rock trains may be formed by débris being thrust out of glaciers at similar places where motion is small. In these instances the fragments are probably torn off under the ice from the flanks of the dividing spurs, and they may be compared with those originating in the middle of a glacier.

REVIEWS.

I.—Geological Guides to Pomerania and Bornholm. By W. Deecke. "Geologischer Führer durch Bornholm." 8vo; 130 pp. and map. "Geologischer Führer durch Pommern." 8vo; 131 pp. Nos. 3 and 4 of Sammlung Geologischer Führer. (Berlin, 1899: Gebr. Borntraegger.)

DR. E. GEINITZ'S guide to Mecklenburg and that of Dr. Beck to the section of Saxon Switzerland south of Dresden have already given a favourable introduction to Borntraegger's series of geological guides. The two next volumes in the series are worthy of their predecessors. They are practical in method, clear in style, and while they are written in language sufficiently popular to be understood by any intelligent tourist, the information is sufficiently precise and definite to give a geologist a clear idea of the geological features of the districts described. Both guides are on the same plan. They begin with a brief account of the topography of the districts; this introduction is followed by a longer general sketch of the stratigraphical geology. The reader, having thus been told what there is to be made out in the district, is informed exactly where to find and how to interpret the available evidence. The books close with a list of the more important geological works on each district and with a full index.

The two districts, though not far distant geographically, are very distinct geologically. Bornholm consists of a granite massif, intersected by diabase dykes and with a fringe of Lower Palæozoic and Mesozoic rocks along the southern coast. The stratified rocks include Cambrian sandstones and 'schiefer'; an Ordovician *Orthoceras* limestone; *Trinucleus* and graptolite shales; and some Silurian graptolite beds. The Upper Palæozoic is unrepresented. Of the Neozoic series there are only a bed of Lias and a Lower Senonian Greensand and Chalk. The glacial beds are important, and are interpreted as belonging to two Glacial epochs—a first period of complete glaciation, and a second glaciation in which ice occurred only on the low-lying borderlands of the island.

The guide to Bornholm is accompanied by a clearly printed coloured geological map on the scale of 1 : 100,000.

Professor's Deecke's guide to Pomerania is necessarily briefer and less complete than his little monograph on Bornholm. The geological series in Pomerania includes beds of Lias, Dogger (Bajocian and Callovian), Kimmeridgian, Cenomanian, Turonian, Senonian, Oligocene, and Miocene. Probably the most important member of this series is the Schriebkreide of Campanian age (*Mucronatus* zone) of the island of Rügen. The principal Cretaceous sections on that island are described, and a map of north-eastern Rügen is a further guide to the best collecting-grounds. The glacial deposits belong to two series, the first being the puzzling Drifts of the Island of Rügen, whose origin and relations have been a vexed question in North German glacial geology from the days of Lyell's description in 1837 until the recent papers of Professor Bonney and Mr. Hill. The second group of glacial deposits belongs to the great terminal moraine of the Baltic Plain.

Professor Deecke is to be congratulated on his guides, which will be useful to geologists and tourists and especially to geological teachers and their students.

MEMOIRS OF THE GEOLOGICAL SURVEY.

II.—THE GEOLOGY OF THE COUNTRY AROUND DORCHESTER. By CLEMENT REID, F.R.S., etc. 8vo; pp. 52. (Printed for H.M. Stationery Office, London. Price 1s.)

THIS Memoir, which is intended to accompany the New Series Geological Survey Map, No. 328, deals with the subject much more fully than do the previously published Memoirs by the same author on the Geology of Bognor, Bournemouth, and Eastbourne. This is as it should be. In such Memoirs we look for a fairly complete account of the geology of the area included within each Survey map, and for a record not only of what the Survey geologists have done, but of what others have done also.

Upper Jurassic rocks and Wealden beds occupy a very small portion of the area described in the work before us; the Upper Cretaceous, Tertiary, and later deposits form nearly the whole of the ground.

The Gault and Upper Greensand are grouped together, under the name Selbornian (as used by Mr. Jukes-Browne); and these deposits, as well as the Lower, Middle, and Upper Chalk, with their palæontological zones, are duly described. The Reading Beds next receive attention. These consist partly of coarse sand and grit, with small splinters of flint and with bands of the characteristic red-mottled clay; but westwards the deposit passes into a subangular flint and chert gravel with a few Palæozoic pebbles. An extraordinary number of swallow-holes occurs in the district of Puddletown Heath and Bryant's Puddle, to which attention was directed many years ago by the Rev. Osmond Fisher. Their occurrence in the Reading Beds is attributed by Mr. Reid to the fact that the strata overlying the Chalk comprise freely permeable sand and gravel with bands of clay. The masses of impersistent clay have served to direct the rainfall to certain spots, whence it descended into and dissolved the Chalk.

The London Clay would hardly be recognized by one whose experience was confined to the London area. In the Dorchester region it consists of sand and sandy loam with septarian ironstone. More interest attaches to the Bagshot Beds, on the extent and composition of which much new light has been thrown by Mr. Reid. By an attentive study of the small mineral fragments in unmistakable Bagshot Sands he has been able to trace the equivalents in coarse gravels, which in some cases have been regarded as Drift; moreover, he has shown that westwards the Bagshot Beds overlap the London Clay and rest directly on the Chalk. The evidence obtained tends to confirm the view expressed by Mr. Starkie Gardner, of an Eocene river flowing from the granitic and Palæozoic districts of Devon and Cornwall, and bringing coarse detritus as well as impure china clay into the regions of Dorset and Hants.

An interesting observation made by Mr. Reid is on the softening of Greensand chert. He noticed fragments so soft that they looked like pebbles of pipeclay, though they soon harden on exposure. This, as he remarks, "will explain the curious way in which the fragments are sometimes dented by each other and pitted by sand-grains."

Among other subjects of interest are the Pliocene deposits of Dewlish, which have been worked out very fully by Mr. Mansel-Pleydell and Mr. Reid. The various superficial deposits, the clay-with-flints, plateau gravels, and more recent alluvial deposits are likewise described.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

The first Meeting of the present Session, 1899–1900, was held November 8th, 1899. W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Cornish Earthquakes of March 29th to April 2nd, 1898." By Dr. Charles Davison, M.A., F.G.S.

The importance of these three slight earthquakes lies chiefly in the unusually clear evidence that they furnish with regard to the origin of the double series of vibrations in one of the shocks, and to the continuous displacement of the seismic focus along the surface of the originating fault. The second earthquake—that of April 1st—was the strongest of the series, and the account of it is based on 89 records from 56 different places. Two distinct shocks were recorded at 25 places, the second being the stronger. The focus of the first earthquake was about a mile in length; that of the second was probably not less than five miles, and its centre being about a mile E. 33° N. of the former, it probably included the focus of the first earthquake. The focus of the third shock was probably included in that of the second. The strike of the rocks near Mullion, a thrust-plane hading to the south-east, the strike of the lodes near the epicentre, and several elvan-courses—are all parallel to the isoseismal axes, or nearly so. Besides the focal transference along the strike of the fault-surface, the double series of vibrations gives evidence of transference down the hade of the fault-surface, the focus of the earlier shock being at a higher level than that of the second.

2. "On the Geological Structure of Portions of the Malvern and Abberley Hills." By Professor T. T. Groom, M.A., D.Sc., F.G.S.

This paper is in continuation of one on the Southern part of the Malvern Hills already published by the Geological Society. In it descriptions are given of the exposed rocks of the Malvern Range from Swinyard Hill to North Hill, the district of Cowleigh Park, Martley, Woodbury, Wallsgrove, and the neighbouring tract of Coal-measures. The Silurian rocks west of the hills are almost invariably inverted, and the Malvernian rock frequently can be found to be overthrust on to them. In several cases there is reason to suspect that slips of Silurian rocks are caught in infolds among the Malvernian rocks. The author concludes that the whole of this district, May Hill, the Old Red Sandstone tract to the west, the coalfields of the Forest of Dean, South Wales, and Bristol, and the Tortworth district, are traversed by a series of related folds, whose axes run in two chief directions intersecting at a considerable angle: the axial planes of one set tend to dip eastward, and of the other in a southerly direction. Overfolding has taken place frequently from the east, less frequently from the south; and this inversion affects the south as well as the middle and north of the Malvern range. The Archæan rocks are thrust on to various members of the Cambrian System in the south and of the Silurian System in the north. The overthrusts are more closely connected with a later movement than with the first folding of the rocks, and while they have not materially altered the nature of the rocks concerned, they have in some cases resulted in the production of schists (mylonites). In some cases a secondary folding has affected the thrust-planes. The intensity of the folding diminished west of the old ranges. The chief movement appears to have progressed in sections from north to south, and the western fronts of different sections show some tendency towards convexity in the direction of movement. While the rocks affected by great movement range from the Archæan to the Lower Coal-measures, the Upper Coal-measures and Permian rest relatively undisturbed on the denuded rocks of the range: thus the range is a member of the Hercynian system produced during Coal-measure time, and probably the two approximately rectangular directions of movement were practically contemporaneous and were produced during the limited interval between the deposition of the Lower and Upper Coal-measures. There is no evidence to prove that the Malvern and Abberley Hills formed part of a coast-line against which the Triassic beds were deposited; for the Upper Bunter Sandstone forms the base of the Trias throughout the district and rests unconformably on the Haffield Breccia, together with which it passed unconformably over the site of the West of England Chain. The present position of the Permian and Trias on the east of the hills is due to a post-Liassic fault of moderate downthrow, which tends to run parallel to the western front of the old range.

CORRESPONDENCE.

THE LIMESTONE KNOLLS OF CRAVEN.

Sir,—According to Mr. Marr the limestone knolls in Craven are due to the rock having been squeezed up, under intense lateral pressure, through the overlying shale. If this be the case, we should find the knolls most pronounced where the pressure has been greatest. Now the pressure, as proved by excessive folding, was greatest along what is now the Skibeden Valley, between Skipton and Wharfedale, but there are no knolls there. The knolls are confined to the region of Thorpe, where the rocks are not much folded and have therefore not suffered great pressure. As the knolls, then, do not occur where, according to the theory of Mr. Marr, they ought specially to be found, the theory cannot be true.

J. R. Dakyns.

Pen-y-Gwrych, Llanberis.
November 3, 1899.

SUBMERGED PHYSICAL FEATURES OF THE MEDITERRANEAN BASIN.

Sir,—Since my return from the Continent I have been engaged in tracing out the physical features, by means of isobathic contours, of the western portion of the Mediterranean, and not without some interesting results. Considering the essential difference in the physical conditions of the Mediterranean and the Atlantic—that is, of an inland sea, with numerous large islands, and the vast sweep of an ocean almost unbroken through a thousand miles from the British Isles to the Straits of Gibraltar—we may well be prepared for differences in the submerged features of each; although it may be assumed that any changes of level which the eastern borders of the Atlantic can be shown to have undergone have been shared by the western portions, at least, of the Mediterranean. The great changes of level, amounting to thousands of feet vertical, which are indicated by the slopes of the continental platform and its intersection down to its very base of 1,000–1,500

fathoms by old river-valleys, must have extended far eastward as well as westward; and may be expected to have left their effects on the submerged Mediterranean border slopes. Such, indeed, is the case, as shown by the isobathic contours, but far less distinctly than in the case of the submerged borders of the Atlantic. In the first place, the great continental shelf of the Atlantic is in the case of the Mediterranean, narrow, and not well defined; and is represented generally by a broken slope, continuous with the bordering lands down to a depth of about 1,000–1,200 fathoms, when it gives place to the gradually shelving floor of the abyssal region, which descends to depths of over 1,500 fathoms. As a consequence of this, and as we might *a priori* expect, the submerged river-valleys are also less clearly defined than those off the coasts of France, Spain, and Portugal. Where, as in these cases, there exists a gently sloping terrace, extending for 100 to 200 miles out to sea, and traversed by deep channels with steep, sometimes precipitous, sides (as in the case of the Loire, the Adour, and the Tagus), it is easy to identify their courses by means of the soundings on the Admiralty charts; but where such channels only traverse for a short distance a steeply sloping surface, the conditions are entirely altered, and they are consequently less clearly recognizable. Notwithstanding this, however, the submerged channels of the Rhône and the Ebro can be clearly recognized by the inward bend of the contours opposite the mouths of these rivers, extending from about the 50 to the 1,000-fathom contours at the margin of the abyssal floor.

I may add, in conclusion, that I have succeeded in tracing Admiral Spratt's channel, between Adventure Bank and Cape Bon, by which the waters of the Levant Basin were connected with those of the Tyrrhenian Sea during the uplift of the entire area to the extent of 250 fathoms (1,500 feet), as explained by Admiral Spratt himself.[1]

EDWARD HULL.

OBITUARY.

DR. HENRY HICKS, F.R.S., F.G.S.

BORN IN 1837. DIED NOVEMBER 18, 1899.

THE mournful news has just reached us (November 21st) of the death of our genial friend and warm-hearted colleague, Dr. Henry Hicks. The son of the late Thomas Hicks, surgeon, of St. David's, Pembrokeshire, he was born in 1837, and was educated at the Collegiate and Chapter School in that city, and at Guy's Hospital, London. He became a member of the Royal College of Surgeons and a Licentiate of the Society of Apothecaries in 1862, and M.D. of the University of St. Andrew's in 1878, practising medicine at St. David's from 1862 to 1871. During that time he commenced his geological researches amongst the older rocks of that neighbourhood. His first paper was communicated to the Liverpool Geological Society in 1863. In the following year, in conjunction with the late Mr. J. W. Salter, Palæontologist to the Geological Survey, he contributed several papers to the Geological Society, British Association, etc. In 1871 he removed to Hendon, Middlesex, and since that time he carried on researches in North Wales and Scotland, the results being communicated in numerous papers to the Geological Society, Geologists Association, and the GEOLOGICAL MAGAZINE. Of late his investigations were confined mainly to the oldest (Pre-Cambrian) rocks of Great Britain, and he has shown that they are exposed in many areas in which their presence had been hitherto unsuspected. Dr. Hicks described many new fossils discovered by him in the Cambrian, Ordovician, and Silurian rocks, and has written several papers on their classification. He published the results of explorations carried on by him in the ossiferous caverns in North and South Wales, in which evidence is given to show that man occupied some of the caverns during a part of the Glacial Period. In 1891 he described the glacial deposits at Hendon and Finchley, and in 1892 he published an account of the discovery of Mammoth and other remains in Endsleigh Street, London, with sections of the deposits in which they were found. He also wrote several papers on the rocks of North Devon, and discovered a rich fauna in the "Morte Slates," which until then were considered to be entirely unfossiliferous. In 1896–7 he published his views on the "Morte Slates" of North Devon and West Somerset in the GEOLOGICAL MAGAZINE. He prepared a new Geological Map of North Wales for the International Geological Congress which met in London in 1888. Dr. Hicks was awarded the Bigsby Medal by the Geological Society in 1883, and served that Society as Hon. Secretary and afterwards as President during the years 1896 and 1897. He was President of the Geologists Association in 1883–5, and was elected a Fellow of the Royal Society in 1885. He was an Honorary and Corresponding Member of many Geological and Natural History Societies in this country and abroad. Dr. Hicks died rather unexpectedly at his residence at Hendon, after only a very short illness, on November 18th, in his sixty-second year. His loss will be keenly felt by his many friends in the Geological Society and the Geologists Association, who appreciated his great abilities and sterling worth.

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[1] Q.J.G.S., vol. xxiii, p. 292.

SIR J. WILLIAM DAWSON, C.M.G., LL.D. (EDIN.), D.C.L., F.R.S., F.G.S.

BORN OCTOBER 30, 1820. DIED NOVEMBER 19, 1899.

A TELEGRAM in the *Morning Post* of November 20th announces the death on the 19th inst., at the age of 79, of this eminent Canadian geologist, who was almost equally well-known and beloved among geologists on this side of the Atlantic.

Sir J. William Dawson was born at Pictou, Nova Scotia, on October 30th, 1820. He graduated at the University of Edinburgh, and returning home devoted himself to the study of the Natural History and Geology of Nova Scotia and New Brunswick. The results of these investigations were published in his "Acadian Geology" (3rd ed., 1878). In 1842, and again in 1852, he accompanied Sir Charles Lyell in his explorations in Nova Scotia, aiding him materially in his investigations. Since 1843 he contributed largely to the Quarterly Journal of the Geological Society of London, the GEOLOGICAL MAGAZINE, and to other scientific periodicals. He has published numerous monographs on subjects connected with Geology, more especially on the Land Animals and Plants of the Palæozoic Period and on the Pliocene Deposits of Canada. His two volumes on the Devonian and Carboniferous Flora of "Eastern North America," published by the Geological Survey of Canada, are among the most important contributions yet made to the Palæozoic Botany of North America. He described *Eozoön Canadense* of the Laurentian limestones, at that time considered to be the earliest known form of animal life.

In 1850 he was appointed Superintendent of Education for Nova Scotia, and in 1855 Principal of M'Gill University, Montreal. He was a member of many learned Societies in Europe and America. Among his works are "The Story of the Earth and Man," 1872, in which he gives a popular summary of geological history; "The Dawn of Life," 1875, an account of the oldest known fossil remains, and of their relations to geological time and the development of the animal kingdom; "The Origin of the World," 1877; "Fossil Men and their Modern Representatives," 1878; and "The Chain of Life in Geological Time," 1880, a sketch of the origin and succession of animals and plants.

In 1882 he was awarded the Lyell Medal by the Geological Society of London in recognition of his original researches in the South Joggins Coalfield, Nova Scotia, and his other valuable contributions to geological knowledge. The same year he was created a Companion of the Order of St. Michael and St. George; and was selected by the Governor-General, the Marquis of Lorne, to be the first President of the Royal Society of Canada. He was also President of the American Association for the Advancement of Science. In the following year he attended the meeting of the British Association at Southport, and travelled in Egypt and Syria, on the geography and geology of which he published several papers. He was knighted by Her Majesty in 1884. In 1886 he served the office of President of the British Association for the Advancement of Science at Birmingham. In 1893 he was elected President of the American Geological Society. He retired from the office of Principal of M'Gill University July 31st, 1893, and was appointed Emeritus Principal, and Professor and Hon. Curator of the Peter Redpath Museum. Some of Sir W. Dawson's more recent works are "The Geological History of Plants," 1888; "Salient Points in the Science of the Earth," 1893; "The Canadian Ice Age," 1894; "The Meeting-place of Geology and History," 1894; "The Historical Deluge in its Relation to Scientific Discovery and to Present Questions," 1895; "Relics of Primeval Life," 1897.

Throughout his long and active career, Sir J. W. Dawson has contributed in a high degree to the advancement of geology and of science generally in Canada, and under his leadership the M'Gill University has risen to be the principal centre of scientific education and research in the Dominion.

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